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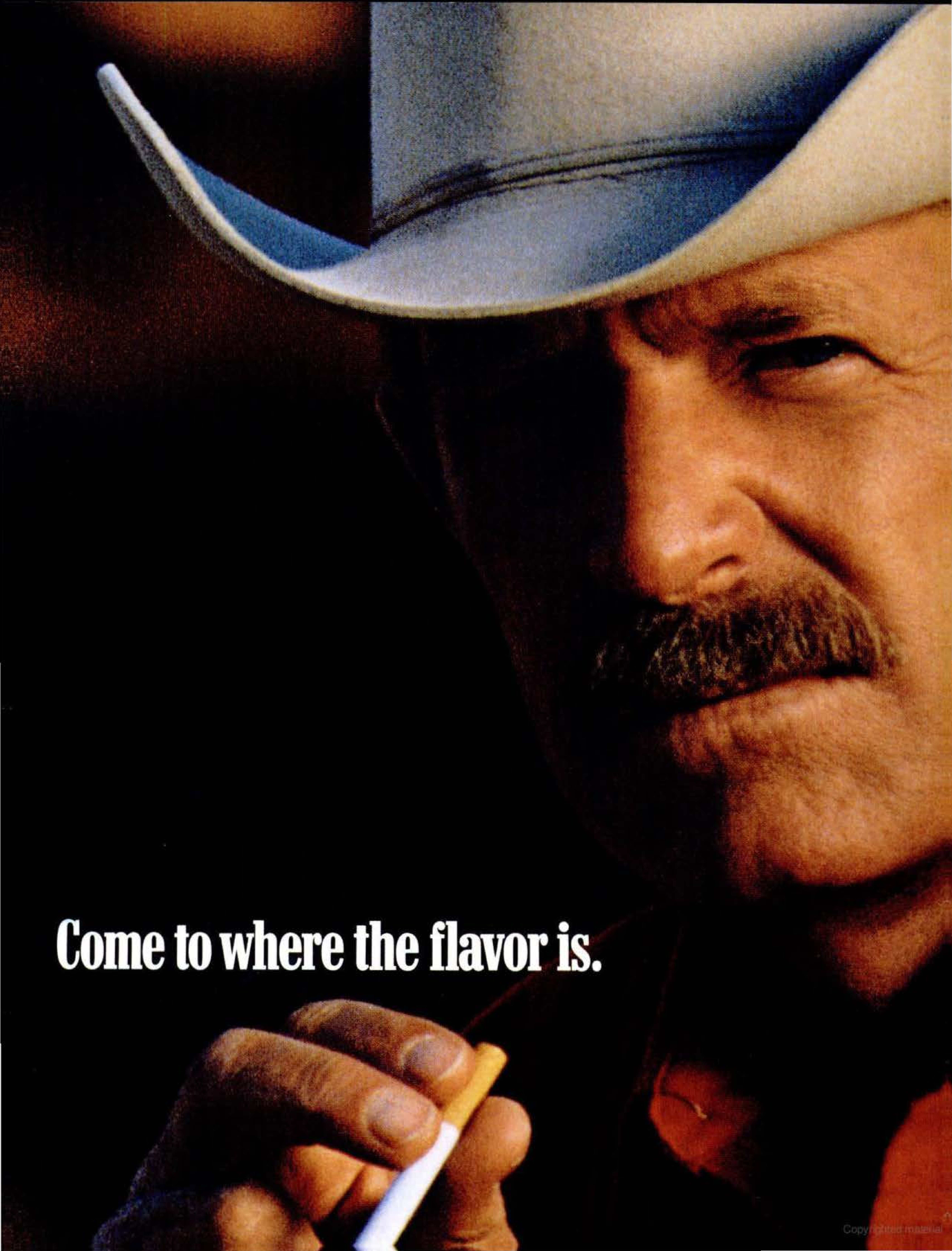
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A1

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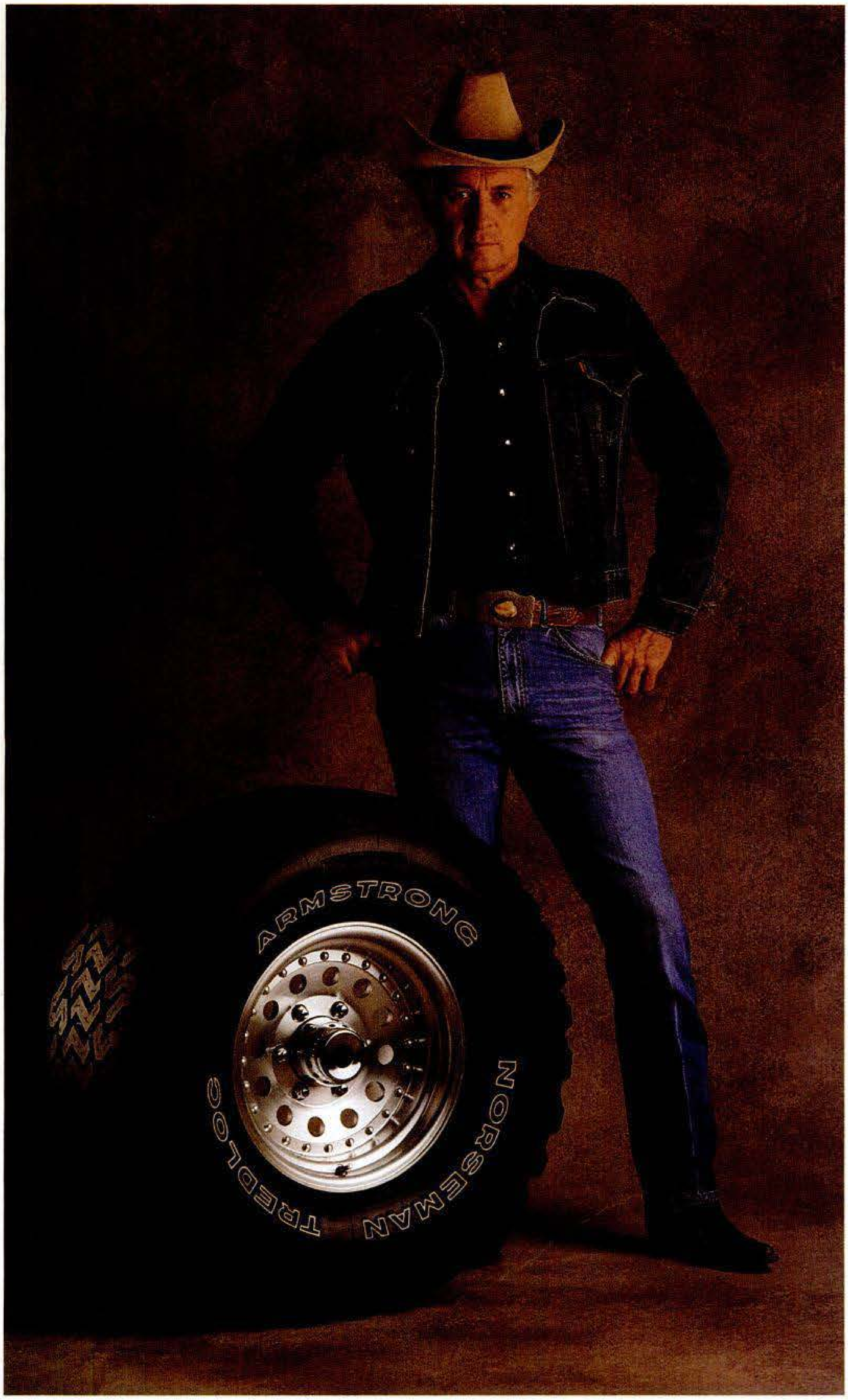
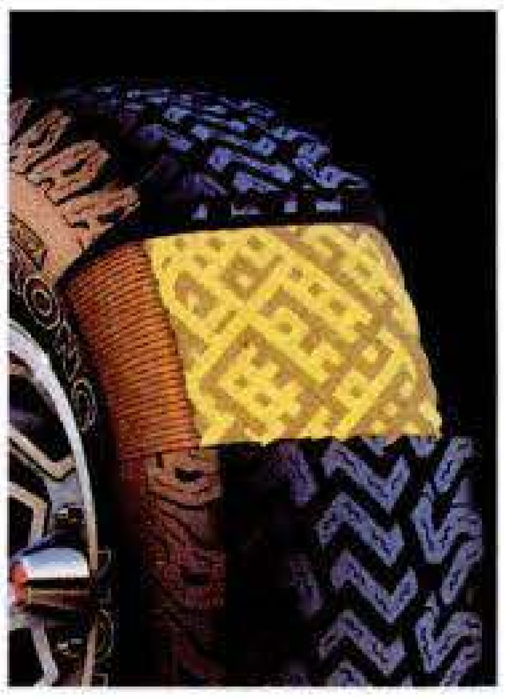


The great outdoors isn't so great when you're in it up to your wheel wells. But since you're not about to change where you go, think about changing how you go. With Armstrong Norseman Tredloc Radials.

Instead of the usual criss-crossed layers of steel belts, Norsemans are wrapped with two continuous woven belts of DuPont Kevlar.® It's a process so unique, it's patented. Kevlar's lightweight, but pound-for-pound, it's five times stronger than steel—so you begin to get a pretty good idea about where the "strong" in Armstrong comes from.

Those Kevlar belts also let the tread flex more easily—so it contours itself to whatever off-road surface you subject it to. And, with low-inflation performance that's equally awesome, it's no mystery why *Off-Road Magazine** calls the Norseman Tredloc one of the best year-round, off-road tires on the market.

Hard to believe a tire so good at riding out tough times can feel so good on the road, but Norseman handling and steering response are nothing short of excellent. Its bigger "footprint" comes from that woven belt construction to allow the entire tread to stay flat on the road.



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*October'89

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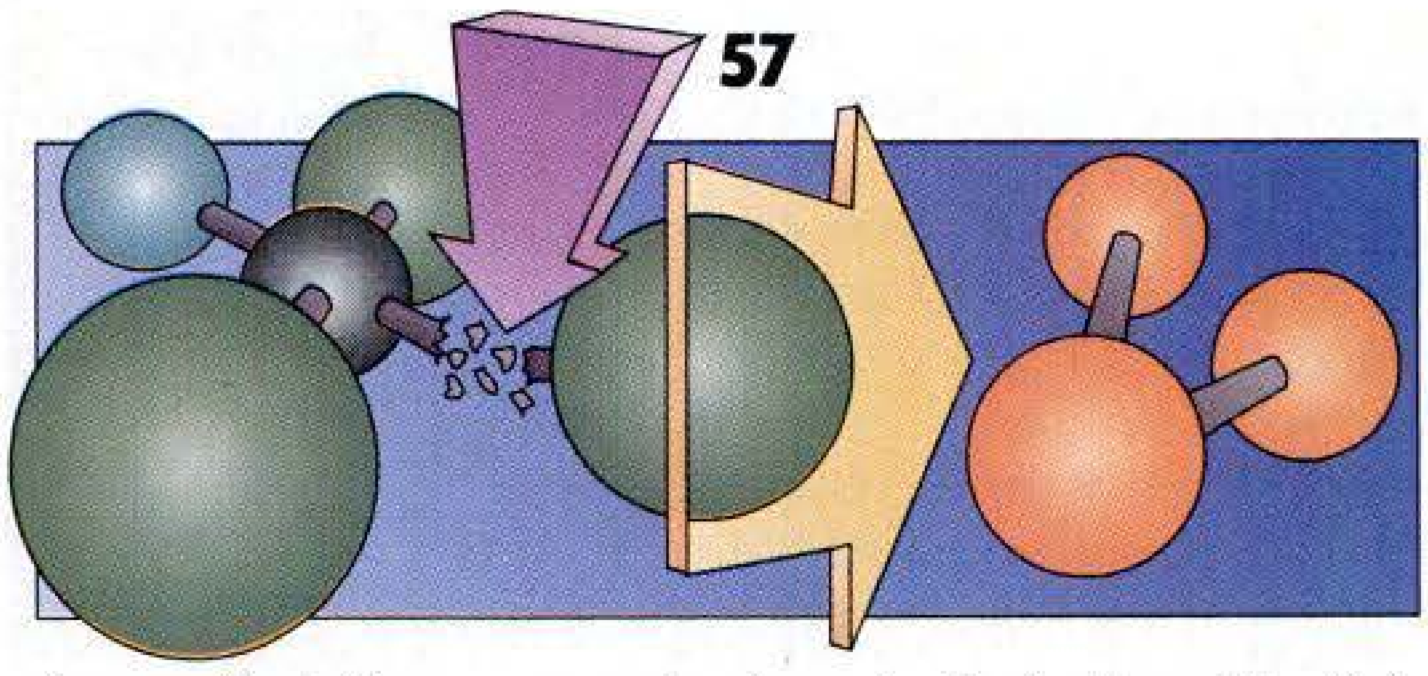
JULY 1990
Founded in 1872/Vol. 237, No. 1

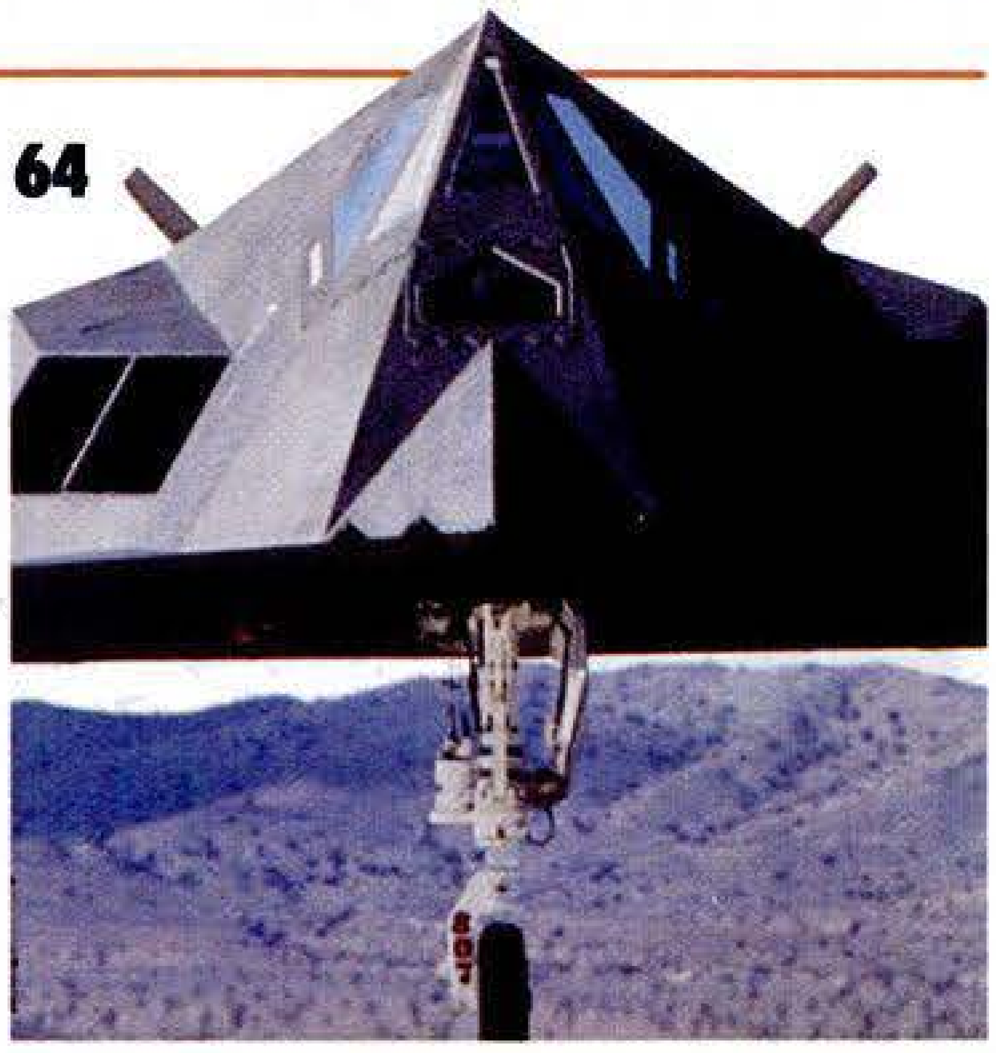
COVER STORY

Ozone-friendly cooling



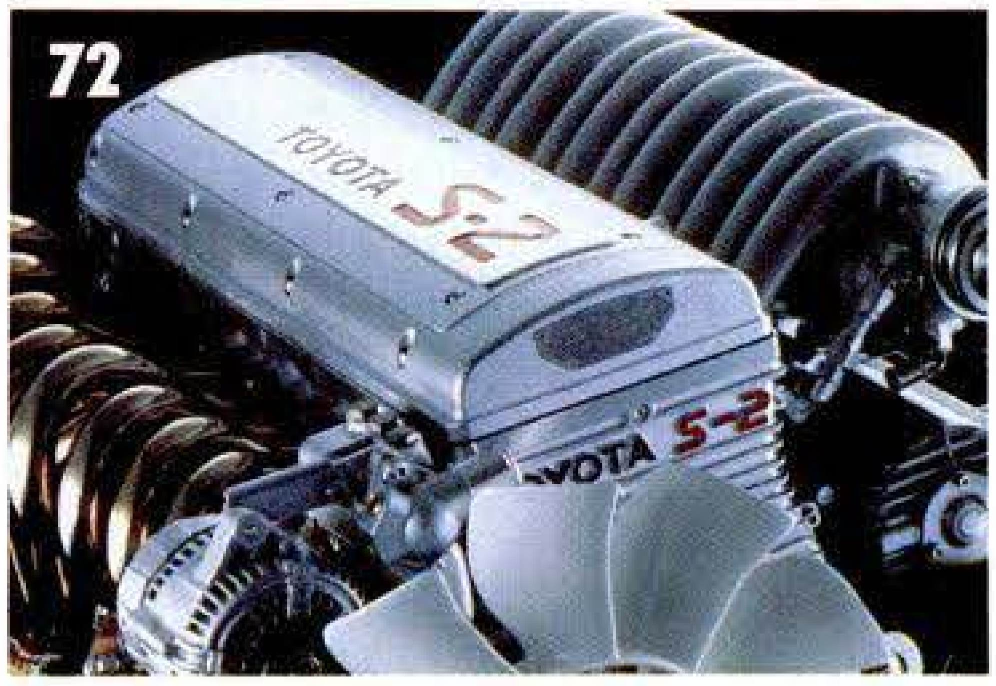
CFCs are among the most ubiquitous and useful of man-made chemicals. But now we know that these organic chemicals destroy Earth's ozone shield. Environmentally friendly substitutes—HFCs and HCFCs—are being tested. The articles in this special section tell how these ozone-benign substitutes will perform at home, and in cars and industry.

Spotlight on stealth



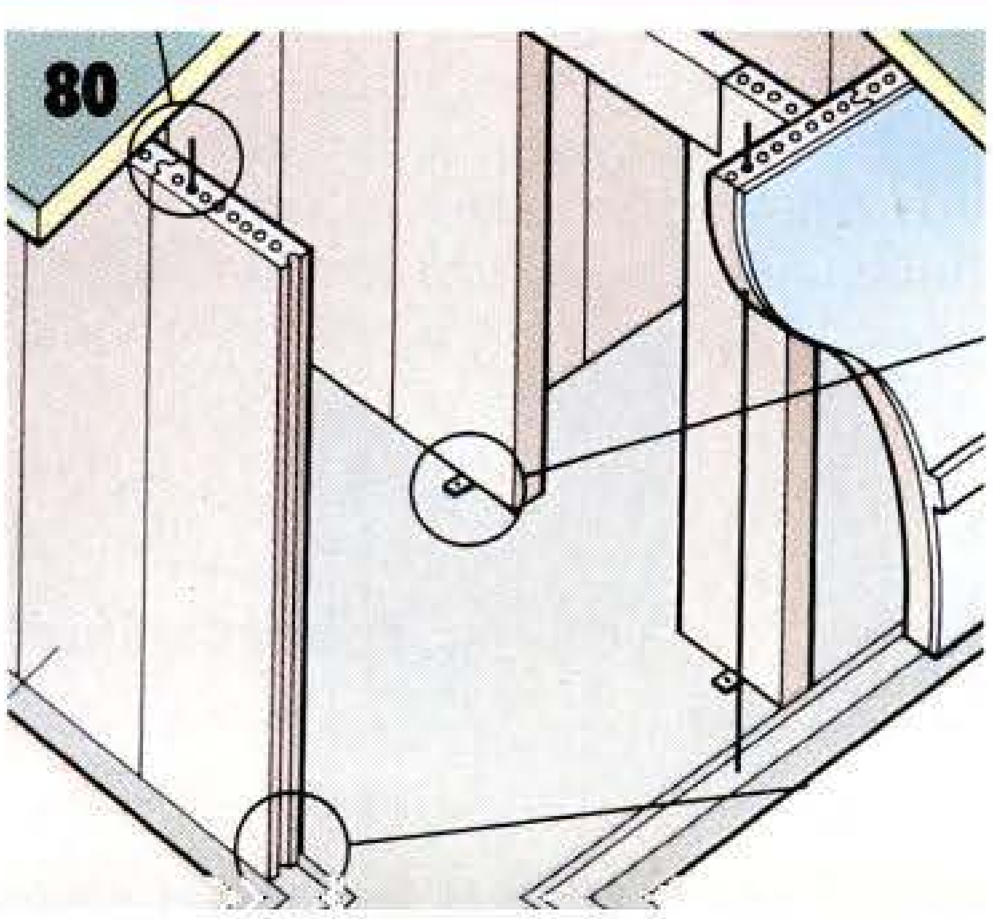
The U.S. Air Force has taken the wraps off its top secret stealth fighter. An up-close look reveals a severe angularity, but pilots report that despite its unusual appearance, the $106-million fighter handles like any other.

Two-strokes



The two-stroke-engine revival was born from advances in microcomputers that made possible electronically controlled direct fuel-injection systems—making the two-stroke design ideal for economy cars of the '90s.

High-fiber house



A company called Acotec mixes wood chips (or rice husks, peanut shells, or waste paper) with concrete to make tongue-and-groove panels that a do-it-yourselfer can use to form a house. And it costs less than conventional methods.

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COVER PHOTOS BY
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What's News

A Hollywood writer I know called recently to share a knotty problem he was having with a script. "It's kind of like an *On the Beach* scenario," he explained, referring to the 1959 doomsday classic of a world decimated by atomic war. But in this writer's story, ozone depletion in the stratosphere is the foil. "What I need to know," the writer pleaded, "is the worst-case scenario. What's the down side of this ozone hole?"

I had bad news for the writer. No melting skin, fried eyeballs, or giant man-eating chinchillas in the offing. Rather, an increase in the amount of ultraviolet radiation threatens agricultural, marine, and human life with subtle, long-term effects. Certainly, if unchecked, destruction of the upper atmosphere's ozone layer will get ugly. Skin cancers will increase. But this statistical burn is far too slow and dreary, I suspect, for a made-for-TV movie.

So don't hold your breath waiting for "The Ozone Hole That Devoured Melbourne." Still, I'm not a Hollywood writer, so what do I know? Perhaps a Godzilla-esque spin is what we need to rally the cause of lifestyles that are less destructive to the environment. For now, until screenwriters find the emotional plot turns that will make the environment big box office, there aren't any shortcuts. We'll all have to invest in hard, inglorious work.

A team of POPULAR SCIENCE editors put in their share to bring you this month's cover story, an overview of scientific and engineering alternatives to the use of chlorofluorocarbons, the man-made chemicals that everyone agrees are the "heavy" in our ozone-hole drama. The good guys seem to be winning, but new technology can't quite cut the cavalry-to-the-rescue role we might like. There is a "giant loophole" in the international treaty that would phase out the use of CFCs, reports Associate Editor Brian Nadel. So, while bright new chemistry promises to generate friendly replacements for a major pollutant, the will and commitment to change seems lacking. Hmm. Maybe my writer friend can get a poignant episode of "thirtysomething" out of that story line.

Environmental issues have been topical in POPULAR SCIENCE throughout its history. Now, the magazine's parent company, Times Mirror Magazines, has announced the formation of the TMM Conservation Council. I urge you to read and respond to the editorial by our company's president and chief executive officer, Francis P. Pandolfi, on page 7, the first of a series of messages that state a corporate commitment to life's teeming diversity.

In space, the great void, one might expect respite from earthly pollution. But there is a cosmic side to the what-do-we-do-with-it-now-that-we're-done-with-it syndrome. Writer Mark D. Uehling points out in his feature on "space junk" that an astonishing 6.5 million pounds of debris threaten every new spacecraft we launch. Think about the threat this poses to the delicate and highly prized Hubble Space Telescope. Michael Shara of the Space Telescope Institute gives even-money odds that the HST will be hit by a marble-size object during its mission. Chances of serious damage are considerably less: About 300 to 1, says Shara. It could be worse, though. The HST is orbiting at a relatively clean altitude. According to Shara, once you get about 1,000 miles above Earth, space is a veritable dump.

For years, chance sightings of the fabled F-117A stealth fighter fueled our imaginations. What would it be like to fly in this odd-looking bird? Now that the Air Force has virtually taken the jet on tour, comes the first public descriptions and viewings. "It feels like you're on the tip of a spear," said fighter pilot Capt. Philip W. McDaniel. "Photographs don't begin to capture its severe angularity," reports West Coast Correspondent J. T. Johnson. Nonetheless, as a public relations gimmick for a high-ticket, high-tech defense appropriation, the Air Force may have waited too long to unsheathe this weapon. In the face of substantial department cutbacks, Defense Secretary Dick Cheney trimmed his request for B-2 stealth bombers by more than 40 percent. Perhaps that was the only prudent thing to do in a world where peace is breaking out—and the world's most advanced $106-million jet, the F-117A, couldn't hit its one and only combat target in Panama.

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At only $499†—complete with all hardware and 100′ of speaker cable—Ensemble is *the* value on today's speaker market. *Esquire* magazine describes them by saying, "You get a month to play with the speakers before you either return them or keep them. But you'll keep them." *Stereo Review* said "It's hard to imagine going wrong with Ensemble."

Unlike satellite systems which use a single large subwoofer, Ensemble features separate compact bass units for each stereo channel. They fit more gracefully into your living environment, and help minimize the effects of the listening room's standing waves.

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We at Times Mirror Magazines (TMM) invite you, the 30 million readers of our nine national magazines (below), to join us in helping conserve the resources that, too often, are taken for granted. This editorial signals the launching of the TMM Conservation Council, a working confederation of our editors and other executives aimed at preserving America's natural resources.

For the editors of our magazines, and for TMM as a whole, the Council represents a public service as well as a longstanding personal and professional interest: We depend on the outdoors for much of our business. Now we are uniting to repay that interest. We want you with us. For the combined voices of 30 million outdoor devotees can bring virtually any politician to instant attention.

So, too, can your buying power. One of the best kept secrets in the U.S. economy is that recreationists spend more than $300 billion annually on their outdoor pleasures—more than the Defense Department budget and more than twice the annual revenues of General Motors. TMM is ready to work with you on the gut-level concerns we share.

The Council has chosen three key issues for initial action:

HABITAT: Crucial wildlife and freshwater fish habitats continue to be disrupted or destroyed by poorly managed logging, livestock overgrazing, farming of marginal croplands, building development, and by industrial and human pollutants. Though many enlightened sportsmen conservationists—including ranchers, lumbermen, farmers, and industrialists—are battling against such destruction, it continues, ironically, in the name of profit.

The real profits, however, lie in recreation: By 1995, for example, on U.S. Forest Service lands, skiing, fishing, hunting, and other leisure activities will generate $5 billion, while logging will bring in only about $1 billion. The Colorado ski industry, whose slopes are

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predominantly on Forest Service land, generates 61,500 jobs alone.

MARITIME WATERS: Marine fisheries and prime cruising grounds for yachtsmen also are under unacceptable pressure from pollution and misuse. Commercial fishermen deplete the waters through destructive practices such as overharvest of juvenile fish and discarding randomly caught species like billfish, dolphins, and whales. In addition, the commercial harvesters' take has long been in absurd disproportion to their numbers, as well as to sound economics. Ten years ago in Chesapeake Bay, a renowned spawning ground for striped bass and other prized marine species, fewer than 40 commercial fishermen took 83 percent of all fish caught in the Bay, while 250,000 Maryland sport anglers got the leavings.

LAND ACCESS: Public access to many of the 724 million acres of public lands managed by U.S. Government civilian agencies—the Bureau of Land Management (BLM), the Forest Service, the Fish & Wildlife Service, and the National Park Service—has been cut off. A recent check by the deeply concerned BLM showed that at least 32 million of its own acres are fenced off or otherwise restricted.

To address these and other issues, we plan future Council editorials. At the same time our individual magazines will press ahead with opinions of their own. At POPULAR SCIENCE, we will continue to expand our coverage of technology's impact on our environment. We will seek out the scientists and the sciences that pose solutions to global warming, the ozone hole (this issue), acid rain, toxic waste, and other threats to the environment. Meanwhile, too, TMM has established a Washington office to work directly with government on our conservation priorities. By the time you read this page, the Council will have:

•Signed working partnerships with the BLM, Forest Service, National Park Service, and Fish & Wildlife Service to enhance careful use of natural resources and to bring prompt action on key legislation, including access to public lands.

•Worked with Sen. Robert Kasten, R-Wis., to strengthen provisions in the 1990 Farm Bill that offer cash to farmers for protecting fish and game habitat.

•Assisted Sen. William Roth, R-Del., and Rep. James Saxton, R-N.J., in developing and introducing bills to prohibit the harvest of striped bass in federal waters; and worked to prohibit the use of drift entanglement nets through the 1990 Magnuson Fishery Conservation and Management Act.

•Joined with Gov. Rudy Perpich of Minnesota to help expand the Environmental Compact of the States (ECOS), an action body to be comprised of governors and aimed at conservation at the state and local level.

These are but a few of our commitments. Join us. Start by completing the questionnaire below. Then mail it to: TMM Conservation Council Executive Director, Dr. David Rockland, Times Mirror Magazines, 1705 DeSales St., N.W., 8th Floor, Washington, D.C. 20036. We want to know your beliefs and what you want done right for America's natural resources.

Francis Pandolfi

President and Chief Executive Officer

CUT HERE

Check the appropriate boxes to indicate your concern on the following conservation issues.

	Agree	Disagree	Don't care
1. Fish and wildlife habitats are being lost at an alarming rate.	☐	☐	☐
2. The public has insufficient access to public lands.	☐	☐	☐
3. Destructive commercial fishing is depleting marine fisheries.	☐	☐	☐
4. Global warming puts human welfare and life at hazard.	☐	☐	☐
5. Water pollution is worsening.	☐	☐	☐
6. Many fish, like game, must be prohibited from commercial harvest.	☐	☐	☐
7. Many household products cause environmental hazards.	☐	☐	☐
8. Pollutants causing acid rain must be eliminated.	☐	☐	☐
9. Toxic wastes threaten all life on Earth.	☐	☐	☐

Please add any other comments you have on conservation. Use extra paper if you wish.

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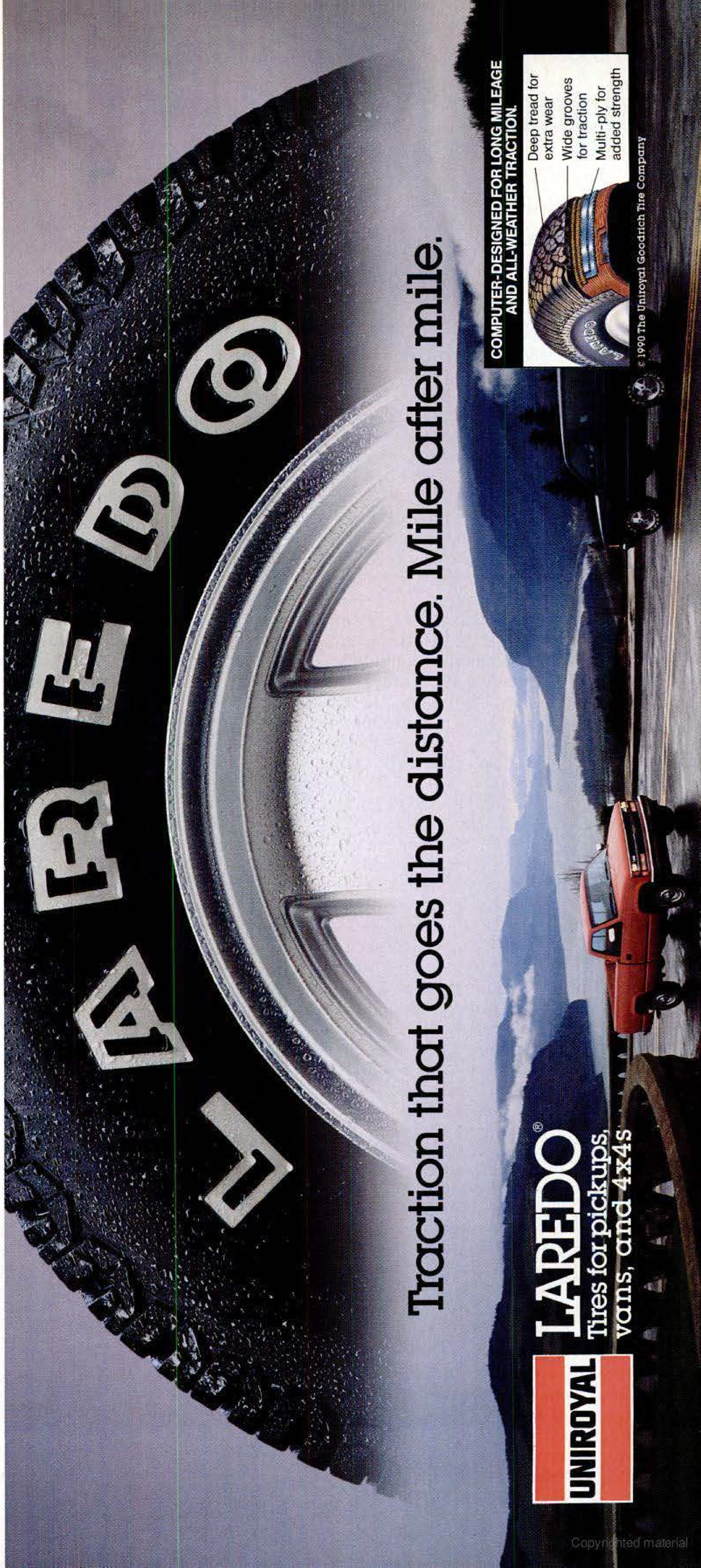
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Readers Talk Back

More nukes

Nuclear power's future in this nation depends less on technology than it does on public recognition that we'll need it, as well as other energy sources, to provide adequate electricity in the coming years ["Next Generation Nuclear Reactors—Dare We Build Them?" April]. That could help Congress untangle the web of regulations and court actions that have institutionalized delay and uncertainty. In-depth polling shows that the public, though skeptical, willingly accepts nuclear plants when it realizes the power is necessary to sustain society; the design choice isn't critical as long as the Nuclear Regulatory Commission, the federal agency charged with safety review, judges the plants to be secure enough. The risks of not having enough electricity are far more detrimental to the economy, quality of life, and the nation's hope for a cleaner environment.

A. David Rossin
Los Altos Hills, Calif.

Rossin was assistant secretary for nuclear energy, U.S. Department of Energy, from 1986 to 1987. He is a consultant to utilities and universities on energy planning and research.

Nuclear-generated electricity is our best option. Some facts: Geothermal power generates toxic mineral wastes from deep within Earth; wind power's low-frequency vibrations cause health problems; hydropower damages coastal fisheries; solar energy requires huge amounts of land; and coal-fired plants that minimize pollutants are expensive. However, nuclear plants create less waste heat, emit almost no carbon dioxide, and have better safety records than conventionally fired plants. We *can* reliably dispose of and monitor radioactive waste. Proper operator training will also ensure safety and protect us from the uninformed knee-jerk reactions of the anti-nuclear faction.

Dennis W. Buller, Stockton, Calif.

Coal-fired plants have caused many problems. In addition to causing pollution from burning, digging for the plant fuel has resulted in workers afflicted with black lung as well as environmental injury from strip mining. The choice is clear: We can destroy the environment with coal while we spend many tax dollars to develop solar or wind power, or we can implement less-harmful nuclear-plant designs that are already under development.

A. Chris Lipkin, Chicago, Ill.

I am an engineer and licensed electrical contractor who could profit from nuclear-plant construction. But I can't support a business that has such a proven record of deceit—the result of having too many in the industry who stand to make tremendous revenues if they can foist their nuclear wares upon us. Using threats of potential disruptive power outages, the industry has falsely maximized the benefits and minimized the costs and dangers to the public. However, nuclear power is already the most expensive electricity source ever conceived—and it will cost still more to decommission old plants and dispose of waste.

Paul D. Stutrud, Rohnert Park, Calif.

You should be ashamed! Your blatantly pro-nuclear article might as well have been labeled "special advertising section" for that thankfully dying industry.

David Pate, San Francisco, Calif.

Why didn't you give equal space to a knowledgeable, prestigious opponent of nuclear power?

Matthew Montanari, Keyport, N.J.

Nuclear power has failed economically, environmentally, and morally. We in the American Hydrogen Association instead advocate a shift from a fossil fuel/nuclear economy, which has a tenuous supply at best, to nonpolluting, cost effective, and renewable hydrogen. By year's end, we plan to make hydrogen a household word.

Sherwin N. Berger
American Hydrogen Association
Tempe, Ariz.

We should use methane gas for electric power and to run autos. The technology is established, it's nonpolluting, and the gas is readily available at our much discussed garbage dumps.

Jay Smith, Fredricksburg, Texas

We don't need new reactors. We can solve our future power needs today by making our homes and businesses more energy efficient.

Richard Riker, Grants Pass, Ore.

False competition

The reader who said solar power was "not competitive" with other energy sources, like coal, missed the point ["RTB," April]. Price is not the only consideration: Hasn't coal caused acid rain and other environmental damage? I would rather gripe about higher energy bills than drive more animals—or humans—to extinction.

Mike Morrow
San Diego, Calif.

Is there a doctor in the house?

In the May "Electronics Newsfront," you incorrectly describe CT scans as "a type of magnetic resonance imaging." A CT scan is computerized tomography, and uses an X-ray beam. Magnetic resonance imaging, however, uses a strong magnetic field and radio waves. Both techniques show bones and soft tissues to varying degrees.

David P. Mayer, M.D., director
The Graduate Hospital Imaging Center
Philadelphia, Pa.

A happy median

The Plymouth Voyager III car-within-a-minivan in the April "Automotive Newsfront" is a fine start to solving a dilemma I have: whether to buy a recreational vehicle or a car and trailer for housing on the road. Any production plans?

John B. Hill, Chapel Hill, N.C.

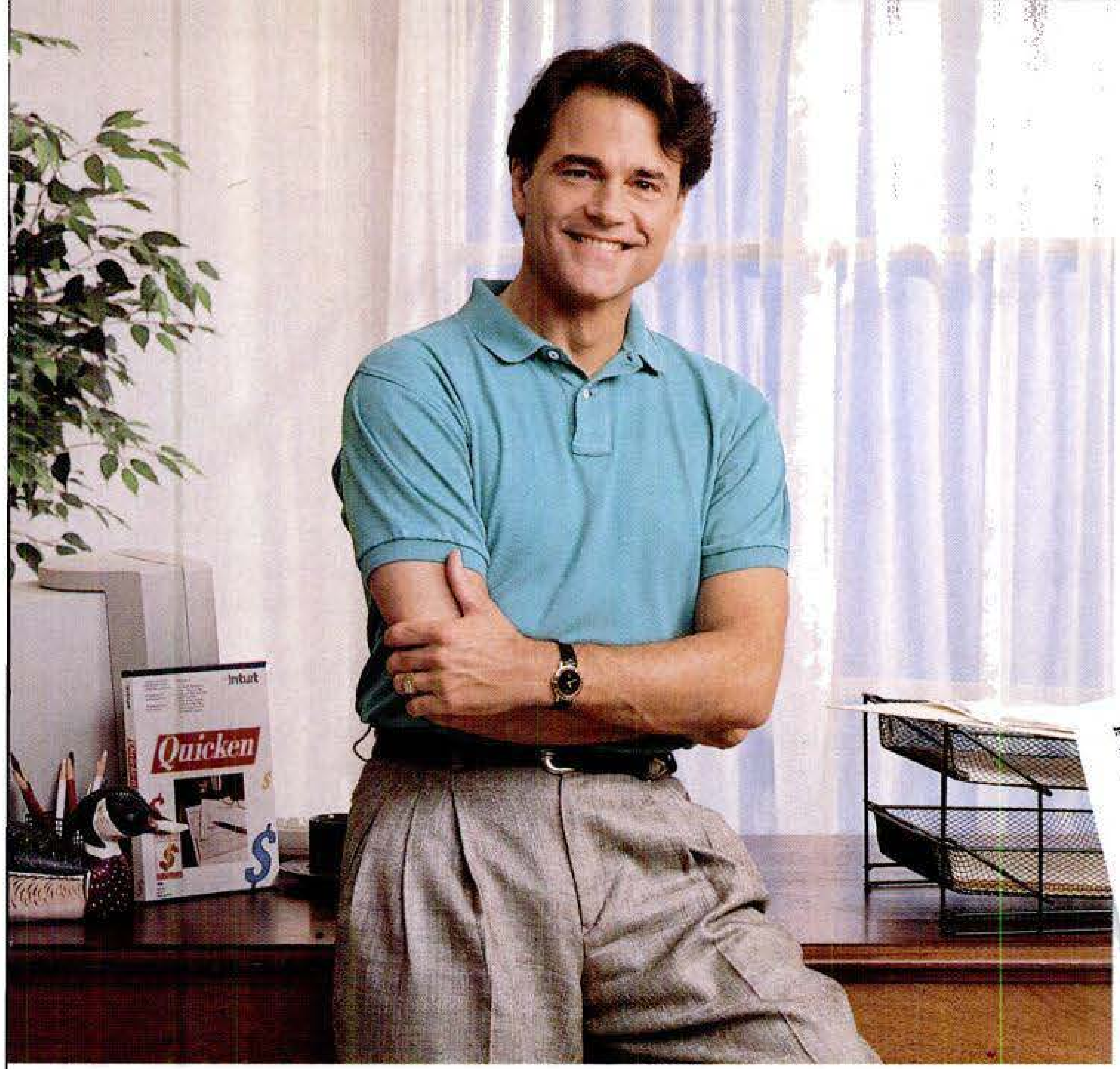
Not yet; so far, the vehicle is just a styling exercise.

To catch a thief

I have a question about spread spectrum, a method of radio transmission ["World Without Wires," April]: Could someone steal computer files by receiving the spread-spectrum signal and "subtracting out" the chip sequence?

Henry Kwan
Brookline, Mass.

No, unless the person happened to have a close replica of the chip sequence, a digital code. The sequence of our wireless computer network, for example, is 8,589,934,591 chips long—impractical to try to find even by computer search. And if the receiver did have the correct sequence, it couldn't participate in the



“If you have to worry about money, you might as well be poor.”

“Quicken's reports tell me where my money goes and how much I have. Now I'm in control.”

“I was making more money. But I wasn't worrying any less. Until I invested $59.95 in a copy of Quicken. Now I always know exactly where my money went. Exactly how much I have. And exactly what I can afford. I never wake up wondering if a big purchase was a big mistake.

The uncertainty is gone. I've never felt so organized about money.

I'm in control now.

Where did my money go? As I pay my bills, Quicken automatically notes each type of expense—utilities, clothing, charity, whatever. Then a simple keystroke gives me a report showing how much I spent in every expense category each month.

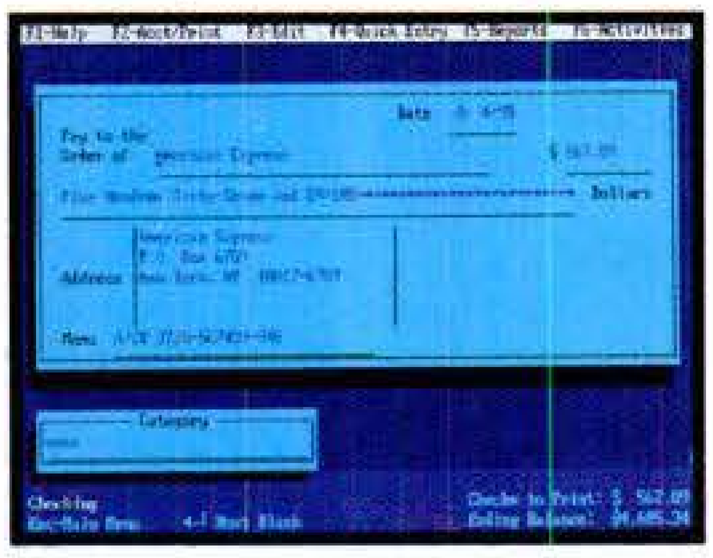
How am I doing? Another keystroke shows my budget vs. actual. Credit application? In seconds I've got a financial statement showing income, expenses, and net worth. Tax time? No sweat. Quicken provides one report with all my itemized deductions.

It's fast.

Time to pay bills? Quicken has “memorized” all my regular payments. I just confirm the amounts and Quicken prints checks for me to sign. I still use my regular checkbook when it's more convenient. Or I can pay my bills electronically through the CheckFree payment service.

It's easy.

I just pulled out the Quick Start Card and typed “install.” That simple. I was up and running in 6 minutes. The screen even looks like my checkbook. There is nothing new to learn. No complicated instructions. I just might read the rest of the manual to see what more Quicken can do.



It's a powerful business tool.

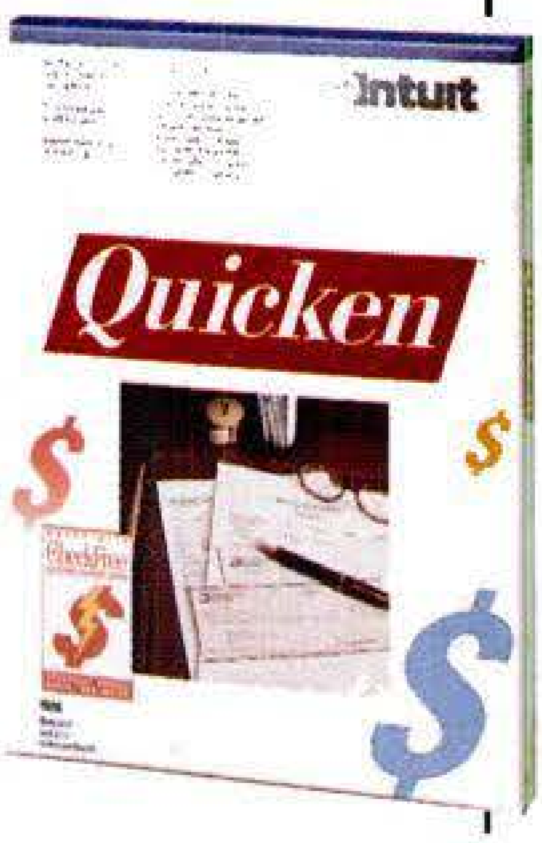
Quicken can help control your business finances, too. It produces P&L statements and balance sheets. Forecasts cash flow. Tracks A/R, A/P, payroll, jobs, clients, properties, and more.

Try Quicken for 30 days at no risk.

Are you making more money and enjoying it less? Order Quicken now. You'll quickly see why it's the best selling financial software in the world. But if you're not satisfied for any reason, return it for a full refund. No questions asked.”

SPECIFICATIONS
IBM: All IBM PC, XT, AT, PS/2, and compatibles with 320K RAM and DOS 2.0 or higher. **Mac:** All with 512K RAM. Both versions work with all monitors and printers. Feature sets vary. Balance Sheet report not available for Mac. CheckFree not available for Mac, or outside the U.S. Unlimited FREE technical support. Not copy-protected.

$59^95



INFO WORLD 1988 PRODUCT OF THE YEAR

“Quicken is ... so easy to use that you may forget you're working on a computer.”
- RICHARD O. MANN, PC TODAY

“For fast checkbook management and tax related accounting, Quicken's intuitive, key-stroke-saving approach is a home business's salvation!”
- RALPH SOUCIE, PC World

PC MAGAZINE
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Bill Howard
9-26-89

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☐ **YES,** I'm ready to take control of my finances. Send me Quicken for only $59.95. If I'm not completely satisfied, I can return it within 30 days for a full refund. Free shipping by air within the U.S. CA residents add sales tax. For coupon orders, allow 10 working days for delivery in U.S., slightly longer in Canada. International shipping extra.

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Readers Talk Back

packet protocol, which includes transmission of incorrectly received packets. Thus, a would-be thief would have no assurance that he would be able to get any computer file, much less the file he might actually want.—Paul K. Kavanaugh, vice president and chief technical officer, O'Neill Communications, Princeton, N.J.

More than kicking the tires

In your test reviews, why don't you tell us how safe the automobiles are? I know performance sells vehicles, but the ability to survive in an accident is the most critical issue.

Ronald B. Greene, M.D.
Philadelphia, Pa.

We agree safety is an important consideration in any automobile purchase. Of course, every vehicle must meet federal standards for crashworthiness. And handling and braking ability, which enable a driver to avoid a collision, are already summarized in our results charts by the slalom, lane-change, and braking-distance tests. In addition, we will soon include a description of each automobile's passenger-restraint system.—Norman S. Mayerson

PS on CD-ROM?

Regarding "CD Libraries: New Power for Home PCs" [May]: When will I be able to purchase the entire 118-year collection of Popular Science on CD-ROM? If that were available, it would justify the cost of a CD-ROM player.

Wayne A. Mann, Chicago, Ill.

*It really depends on the demand for such a "library." You're the first to ask.
—Fred Abatemarco*

Doing our part

Many organizations evaluate cars, but Popular Science is the only one that devotes a section to "prices, parts, and service." I like knowing which cars have windshields and alternators that cost hundreds of dollars more than those of comparable cars.

Richard Carman, Clinton, N.Y.

Sticky business

I read with great interest the item on CBT and VHB adhesive tapes [Strongest Tape?, "Home Newsfront," Feb.]. As a distributor of specialty tapes (including VHB), I can say that their capabilities are tremendous, but not without limitations: Only use VHB or CBT tapes on nonporous surfaces; always apply the tapes at room temperature; and you may need mechanical fasteners at key stress points. If any readers would like to experiment with small amounts of VHB tapes, I would be glad to sell single rolls. Call (800) 882-7348, or, in New York state, (516) 488-5900.

Andrew Machover
Vice president, sales
Tape-Rite Co., New Hyde Park, N.Y.

Sink or swim?

I'm concerned about Aquabuoy, which you featured in "What's New Recreation" [Feb.]. The device straps on your wrist like a watch and inflates to a flotation pillow. After testing it on a recent TV show, however, a water-safety expert gave it a bad review, and didn't recommend using it.

Robert Wong, Bedford, Texas

Easy to wear uninflated, Aquabuoy provides support in water until you can reach shore or help comes. Of course, it is not a life vest—which is indisputably the best protection from drowning. Unfortunately, few people wear the bulky vests. In the TV program mentioned, a person using an Aquabuoy let go of it and allowed his head to submerge. The same thing could happen with a Coast Guard-approved flotation cushion. The Coast Guard says it has neither approved nor disapproved Aquabuoy because it does not yet evaluate personal flotation devices on recreational boats.—Ron S. Ekovich, Pro Technology, Leesville, S.C.

Metal mixup

The catalyst for the rapid hydrogen exchange reactions was explained incorrectly in "Night and Day Solar" [Feb.]. We use nickel for doping the magnesium powder, not tin.

Alfred Ritter
Max-Planck-Institut
Für Strahlenchemie
Mulheim, West Germany

Wrong-way inlet?

The illustration of Scaled Composites' Mud Fighter plane, showing the engine inlet on the pilot's right, is contrary to the text ["Wild Wings Reshape the Way We Fly," Feb.]. Which is right?

Harry C. Wiersdorfer
Hamburg, N.Y.

The engine inlet is on the pilot's left, as stated in the text. We based our illustration on artwork supplied by Scaled Composites that mistakenly showed the engine inlet on the right.

But they have potential

Please deliver us from unimaginative articles like "Slight of Hand Computing" [March]. You chide these computers as being "not for serious users" without recognizing their tremendous potential. Many of us who travel have dreamed of such a machine. As for the lack of software, some existing programs, including programming languages, can be loaded via the serial port and seem to work properly.

J. E. Schoof
Ardrossan, Alberta, Canada

Fie on sky spies!

After reading the March article "Space Spies," I'm convinced we're governed by paranoids who spend billions of dollars on harebrained schemes. They've been invoking the Russian bogyman as a justification for "defense" spending since World War II. If we redirected that money, we probably could solve a lot of our environmental problems.

Joseph W. Engels, Gravois Mills, Mo.

These old tools

I read about the "new" neodymium magnet with some amusement ["What's New Tools," Jan.]. We have been making such a magnet for over four years. Unlike the model you depicted, ours is also telescopic, and when you take the top off, it's a ballpoint pen!

Les Adam, president
AZ Industries, Ash Flat, Ark.

Editor's notes: For more information about Sparfil blocks ["Lightweight Block, Heavyweight Insulator," May] address inquiries to: Sparfil International, 8241 Keele St., #15, Concord, Ontario L4K 1Z5, Canada; or, Sparfil Block Fla., Box 270336, Tampa, Fla. 33688.

The price of the Trace Marker, a stamper in the June "What's New," is now $102.50.

Address letters to Readers Talk Back, Popular Science, 2 Park Ave., New York, N.Y. 10016. Or fax your letter to us at (212) 779-5468. We reserve the right to edit for space and clarity and cannot answer unpublished letters.

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NIGHT LIGHTS AREN'T JUST FOR THE KIDS' ROOM.

Remember when you were a kid how good a night light used to make you feel? Well, high-efficiency outdoor lighting can do the same thing for your home. Because a house that's well-lit on the outside is one that's much safer for you. And one that's a lot less inviting to prowlers. If you'd like to receive more information on how to use high-efficiency outdoor lighting to enhance the safety, security and beauty of your home, contact your electric utility. Because even a kid knows a night light can help keep the bad guys away.

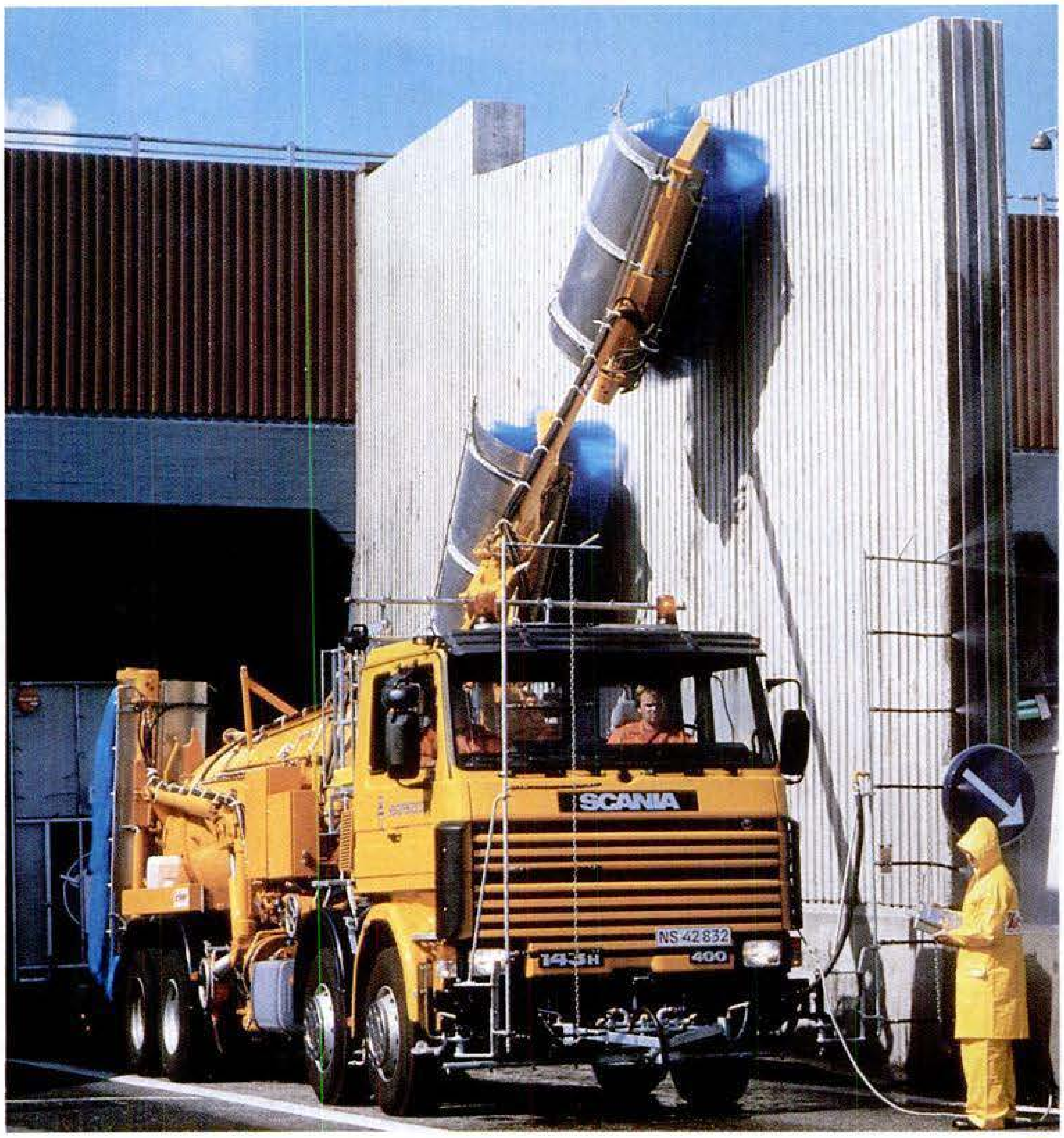
YOUR ELECTRIC UTILITY

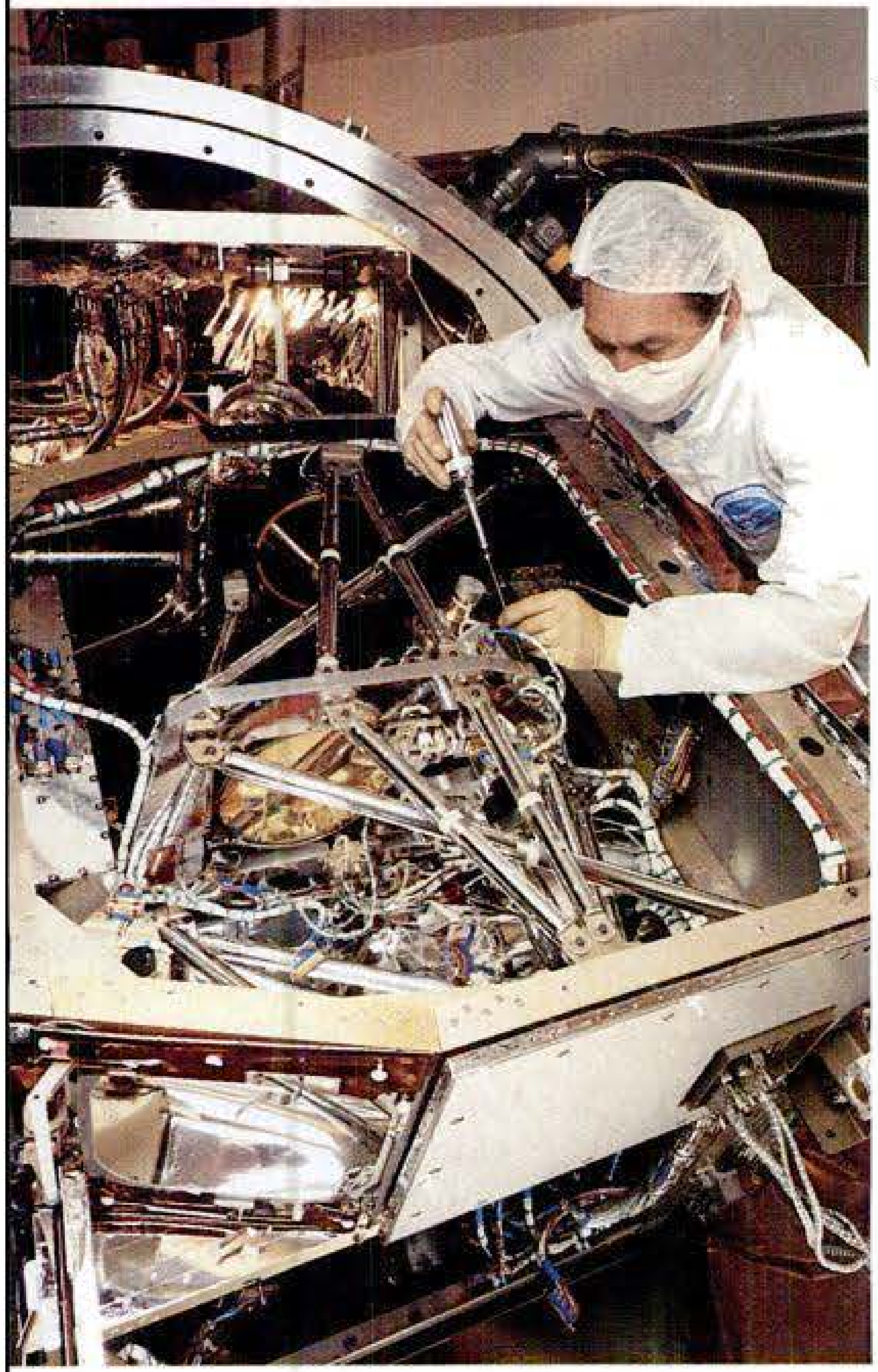
BY JUDITH ANNE YEAPLE

What's New

Cart smart ▲

Wheel a cooler to the beach or haul up to 200 pounds of mulch to your garden with this lightweight cart made of plastic tubing and mesh. Use the CarryOr's push-button snaps to fold it quickly when not in use or to disassemble and stow in a nylon sack. An optional aluminum tow bar attaches to a bike seat. Seair Dynamics, 3980 Airport Rd., Boca Raton Airport, Boca Raton, Fla. 33431.



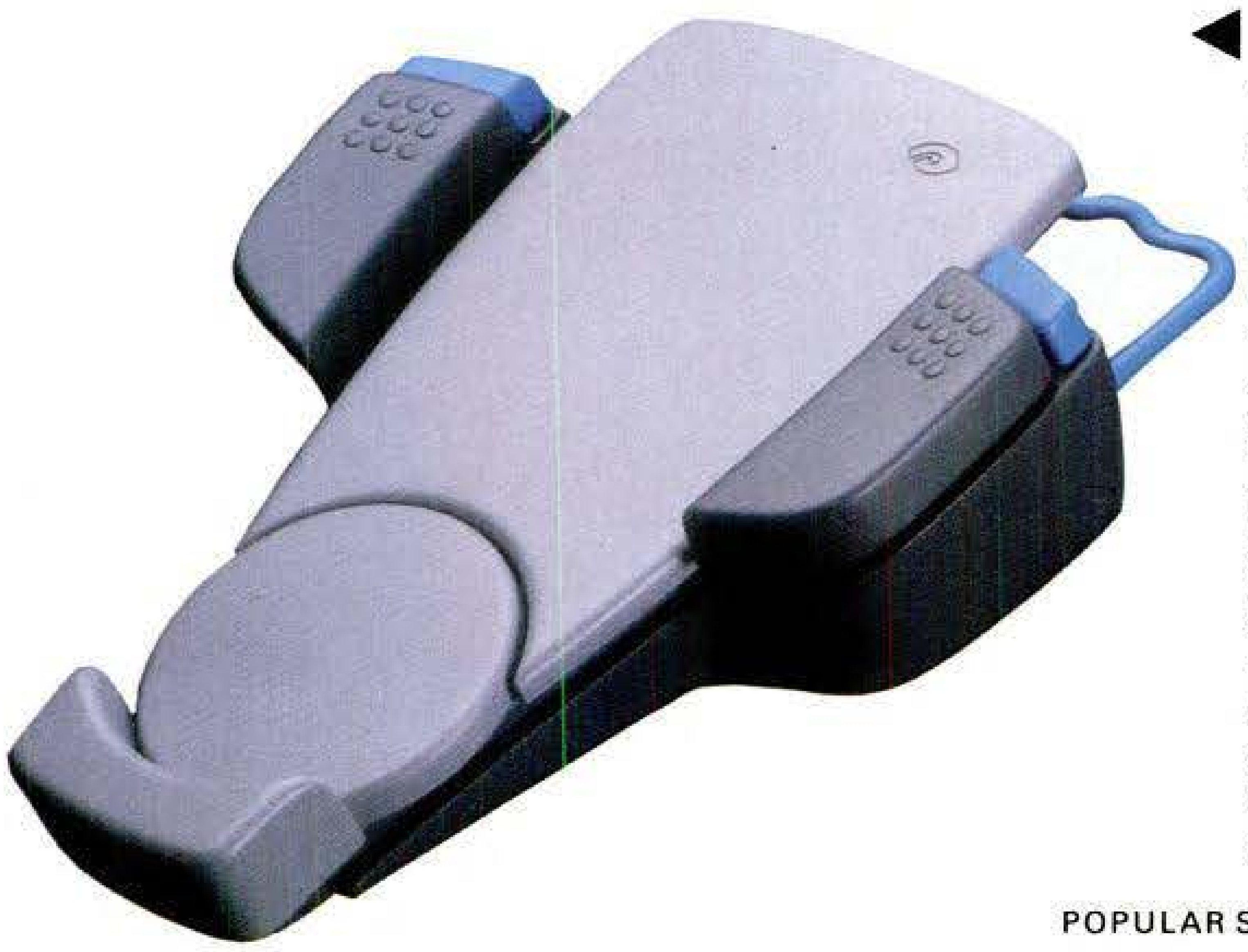


◀ Feel the heat

British scientists hope to study the thermal structure of the atmosphere with their Improved Stratospheric and Mesospheric Sounder, one of 10 instruments to be launched in 1991 aboard NASA's Upper Atmosphere Research Satellite. ISAMS' infrared detectors, cooled to minus 190 degrees C, will measure heat radiating from Earth's horizon.

Tunnel scrubber ▲

In Denmark, vehicle-exhaust soot and salt are scrubbed from tunnels and bridges with this soap-saving machine from Zellinger of Austria and Saab-Scania. Three brushes—one on each side and one on a longer "arm"—enable the truck to wash the tunnel sides and roof. Equipped with a 14,000-liter tank, the machine consumes only one-tenth as much detergent as manual washing.



◀ Fancy footwork

When eye surgeons work, they use a multi-task hand piece to cauterize, cut, rinse, and do other surgical work. They select each function with a separate foot pedal. Now Alcon Surgical in Irvine, Calif., has combined five pedals into one, with two dual-action switches flanking the main pedal. The result: no more groping for the correct pedal.

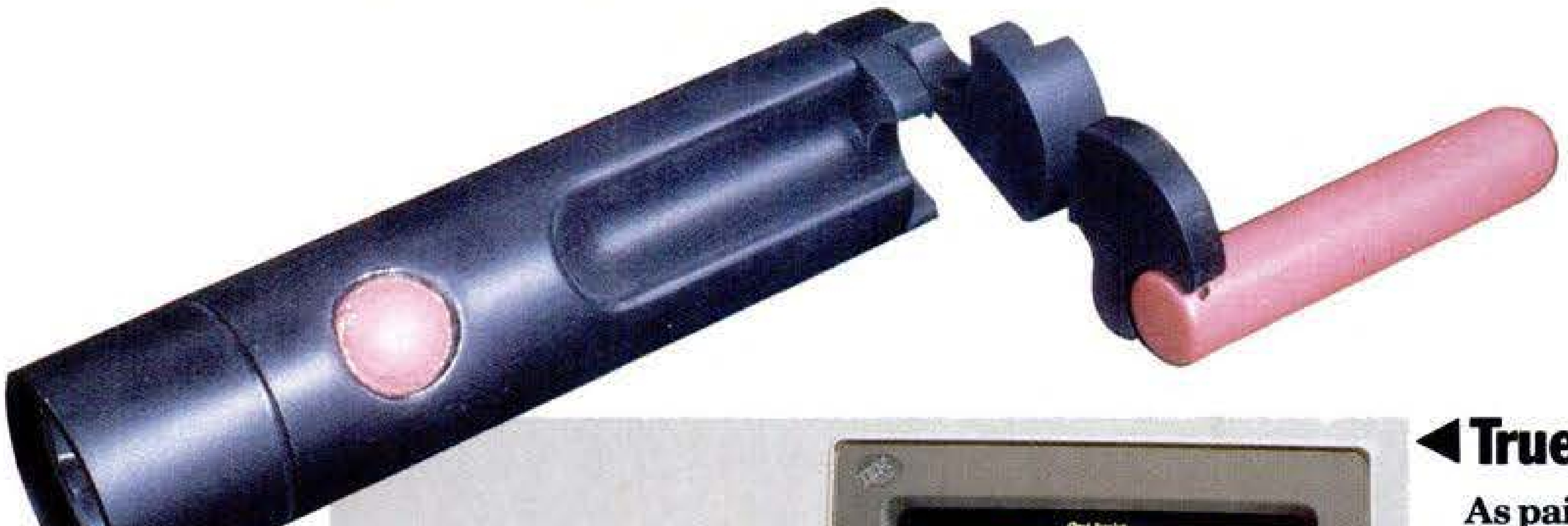
What's New

130-mph kit copter ▶

RotorWay's updated two-seat kit helicopter, the Elete, tops older models with a maximum speed of 130 mph and a range of 340 miles. When you complete the $42,000 kit, RotorWay provides a two-stage flight training to get you up in the air. RotorWay Aircraft, 300 S. 25th Ave., Phoenix, Ariz. 85009.

◀ Super scooper

This nautical trash collector scoops up debris from lakes and harbors in a seven-foot-wide swath. Its unique filter system, a conveyor belt made of 95 steel-cable strands, collects everything from cigarette filter tips to two-foot-wide shipping crates. Inventor Bill Hamilton of Newport Beach, Calif., says the craft can also be adapted to skim spilled oil off the water. This attachment, a large drum covered with a special material, can collect 450 gallons of oil per hour. The $35,000 Water Rake is powered by three 10-hp outboard motors.



Human-powered flashlight ▲

This futuristic flashlight illuminates when its built-in generator is cranked. The flashlight's nickel-cadmium batteries recharge with as little as 30 seconds of cranking. Designed by Charles Babboni, a student at the Milwaukee Institute of Art and Design, the flashlight captured a top prize from a local chapter of the Industrial Designers Society of America.

◀ True colors

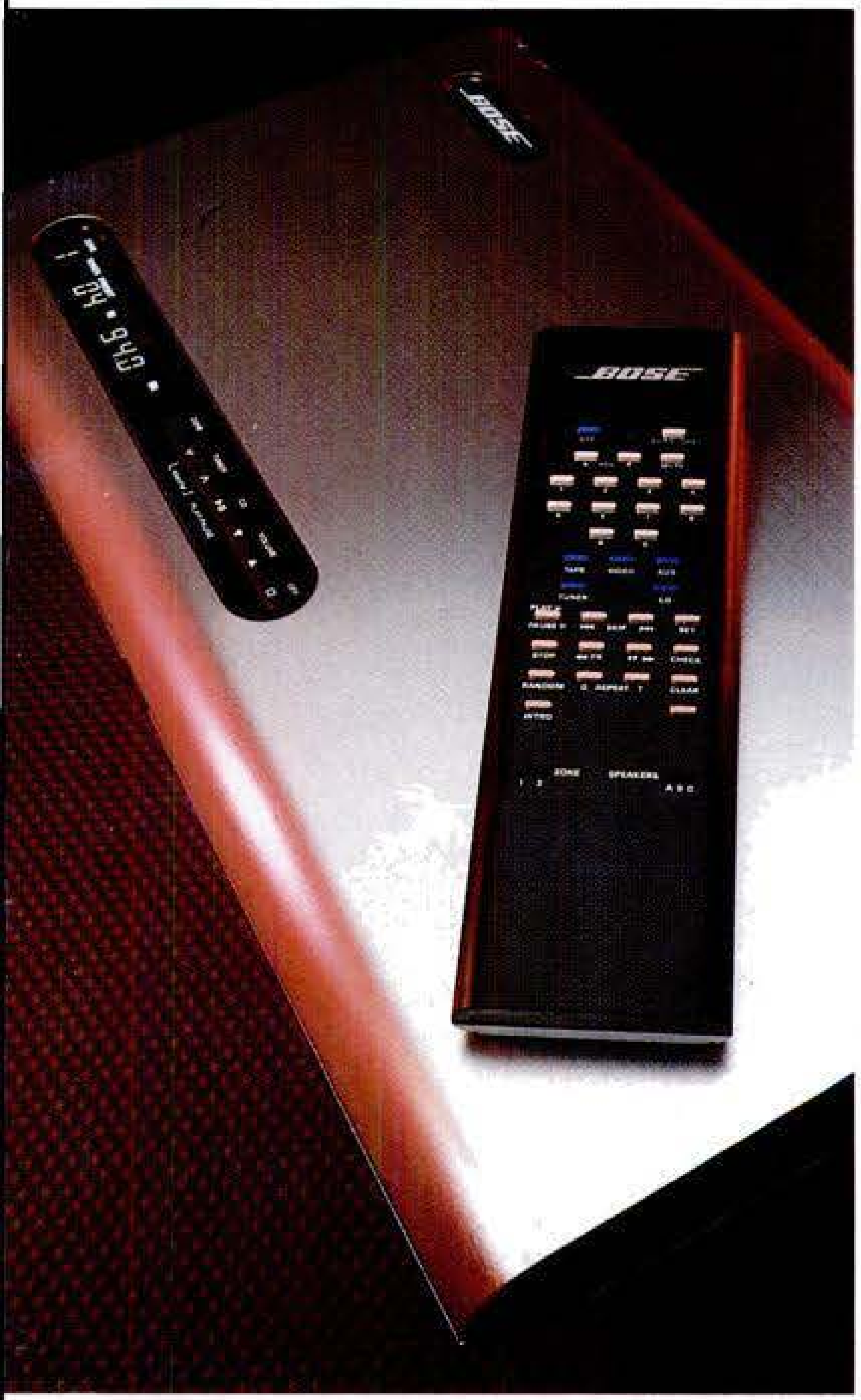
As paint, textile, and plastic manufacturers know, matching colors is difficult because a color is often a mix of several basic colors. This spectrophotometer from X-Rite Inc. (Grandville, Mich.) measures the exact amount of each basic color in a sample then describes it in the international color standards code. The portable X-Rite unit is $8,000.

BY WILLIAM J. HAWKINS

What's New ELECTRONICS

Just add speakers ▶

The top slot on ADC's CD changer accepts a six-disc magazine. The bottom slot lets you play a single disc at a time. Up to 32 tracks per magazine can be preprogrammed, and an additional memory stores the locations of up to 60 discs held in any of 10 magazines. Need more? The SoundStation is a complete AM-FM receiver too. The 60-watt-per-channel model 1440 is $700.



◀ Door phone

Who's at the front door? Pick up the phone to find out. The Telebell System connects your phone system with an outdoor speaker. When you're home, speak to a visitor from any phone in the house. When you're not, Telebell calls you at a remote phone for communications. From United Telesis Corp. (6488 Avondale Dr., Oklahoma City, Okla. 73116), it's $250.

◀ Face lift

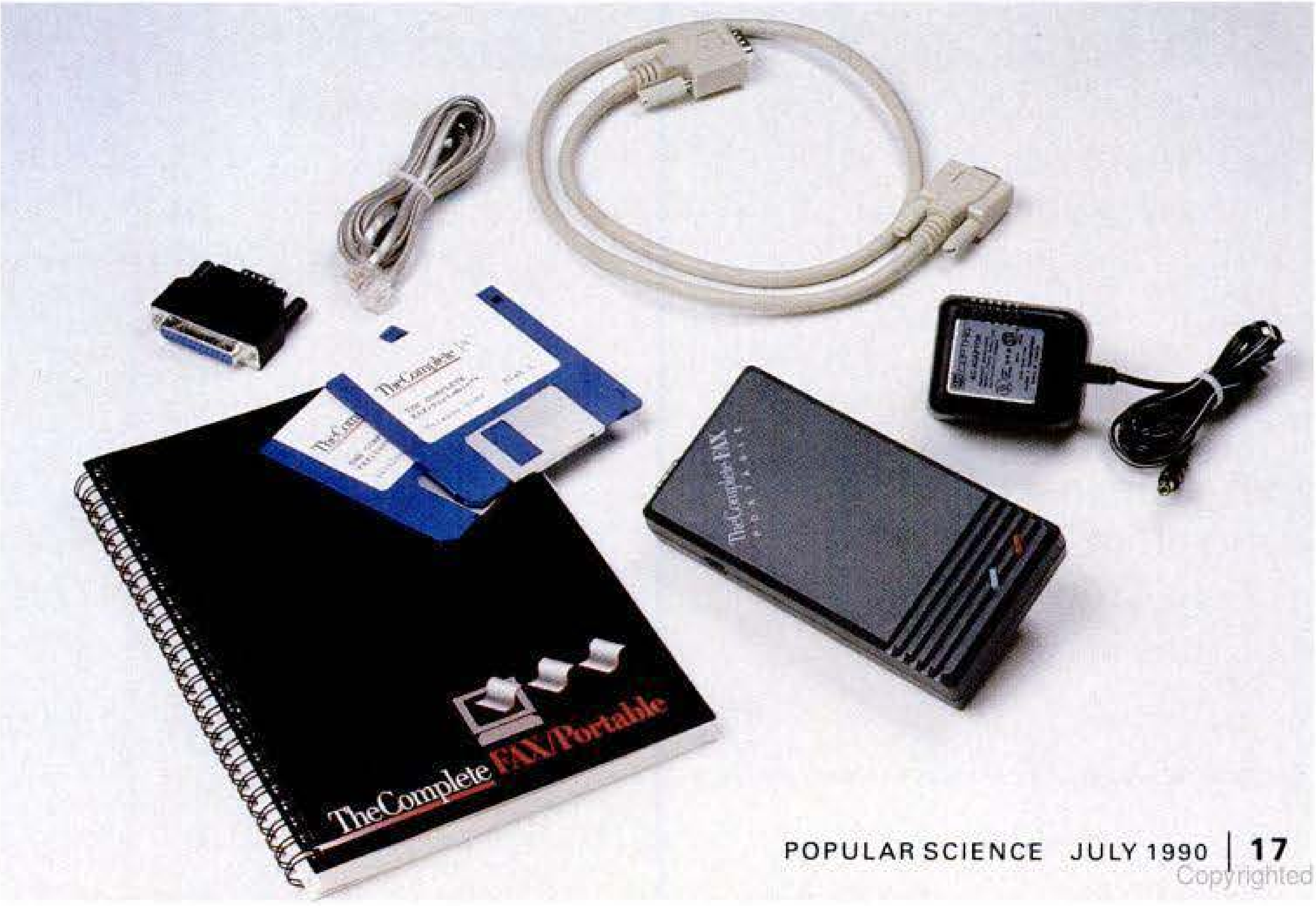
Like the face plate on Pioneer's DEH-750 instrument-panel-mounted CD player? Crooks don't. Reason: The snap-off face—with all the controls—is removable. When you leave the car, take it with you to make the remaining player useless to thieves. The AM-FM/CD 25-watt unit is $530.

Two-zone stereo ▲

Bose's Lifestyle AM-FM/CD music center lets you play two different sources at once: For example, play a CD in the living room, while someone else listens to FM music in the den. The remote control lets you operate the music center from anywhere in the house. Price: $2,739, including a remote and speakers for two rooms.

Pocket fax ▶

Attach the pocket-size Complete Fax/Portable to the serial connection of your PC. Result: Send and receive fax messages on the go via your portable computer. The battery-powered unit is compatible with all Group III fax machines. It's $499 with cables and software from The Complete PC (1983 Concourse Dr., San Jose, Calif. 95131).



Four-wheel drive, rear anti-lock brakes and peace of mind come standard.

The new Electronic 4-Wheel Drive Ford Aerostar with rear anti-lock brakes makes peace of mind a new standard feature for you and your family. That's because this Aerostar gives you improved traction and control in all kinds of weather.

Full-time traction and more controlled braking.

Aerostar's sophisticated 4-wheel drive is a full-time system which electronically senses road conditions and adjusts the amount of power given to each set of wheels accordingly. The rear anti-lock brakes are designed to prevent rear wheel lock-up and help you make straight stops.

Powerful 4.0L V-6, standard.

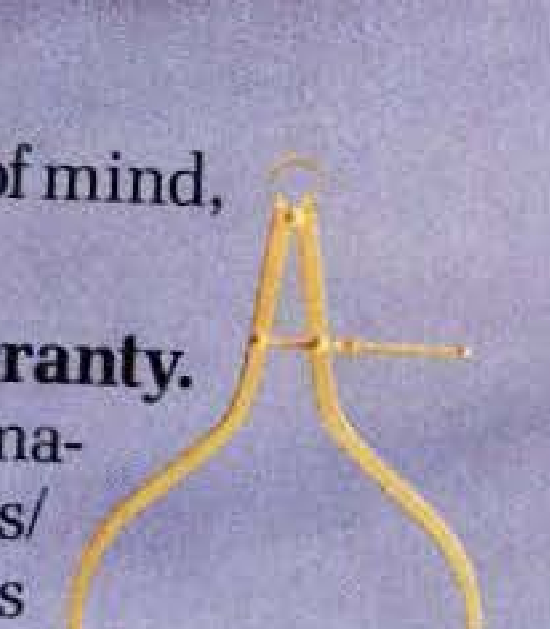
Advanced technology isn't all there is to the Aerostar story. In addition to its standard 4.0L V-6, the new 4WD Aerostar offers attractive styling, a comfortable interior and impressive capability. Put this all together and you've got a

Buckle up—together we can save lives.

vehicle that gives you not only peace of mind, but pride of ownership, too.

Transferable 6/60 powertrain warranty. Covers you and future owners on major powertrain components for 6 years/ 60,000 miles. Ask to see a copy of this imited warranty at your Ford Dealer.

1990 *Motor Trend* award-winner. Recently, *Motor Trend* selected he 4WD Aerostar as the winner of its prestigious 1990 "Truck of the Year" award. Once again, Ford's commitment to quality and philosophy of continuous improvement pays off.



New 4WD Ford Aerostar

Have you driven a Ford...lately? Ford

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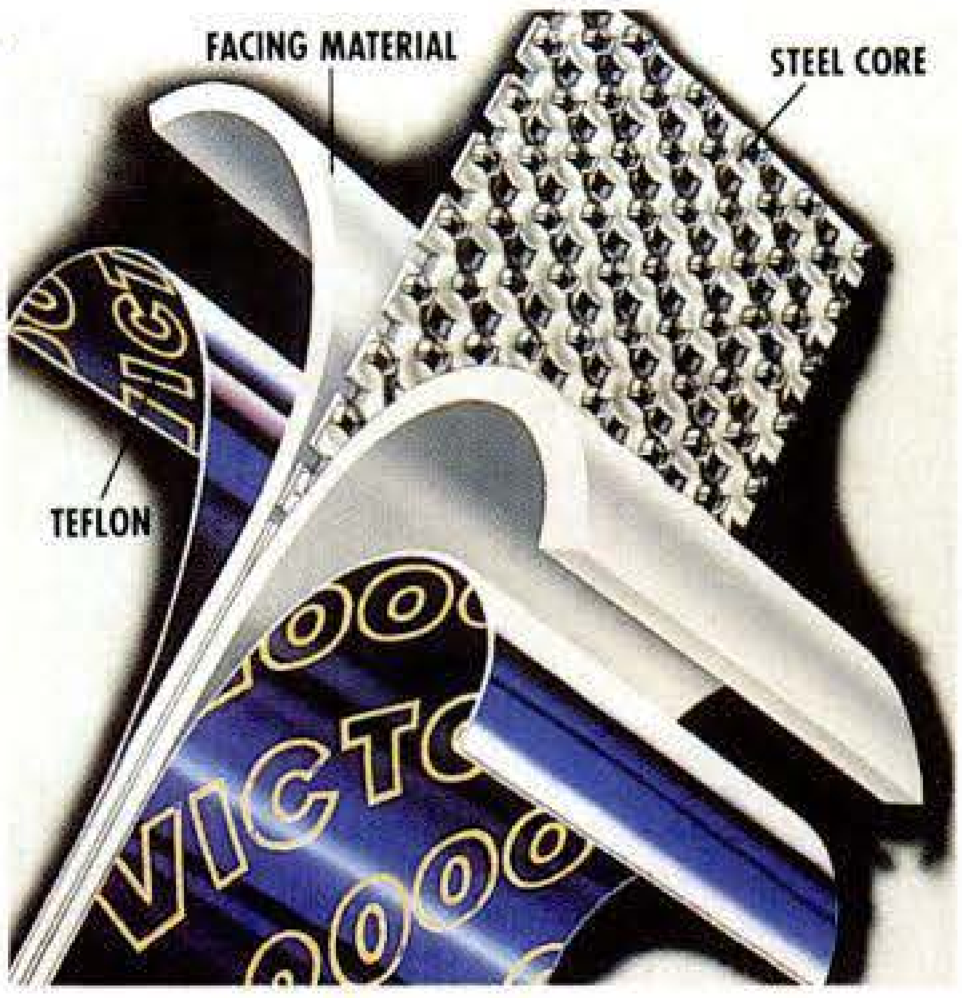
BY BRIAN NADEL

What's New AUTOMOTIVE

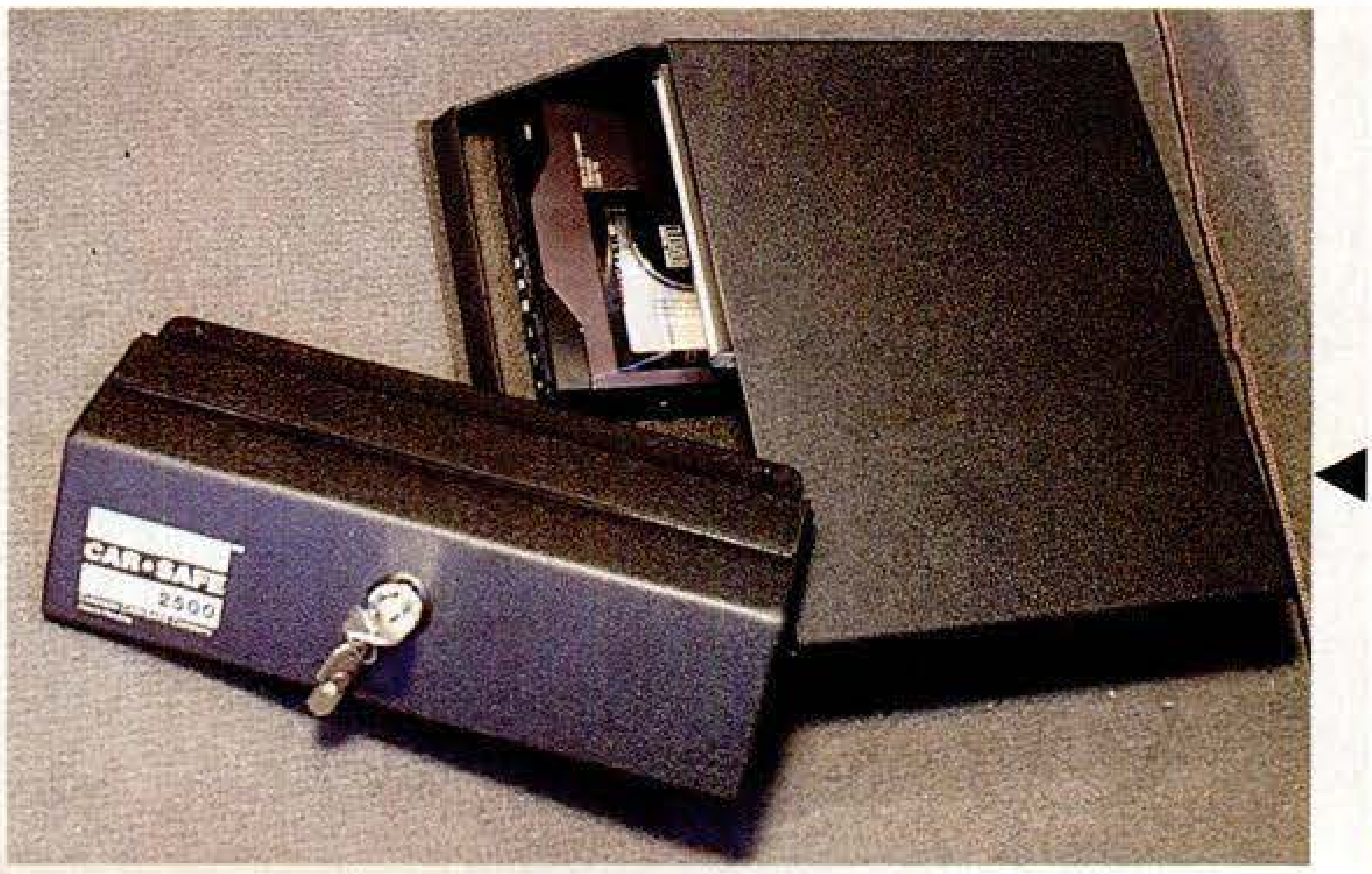
High-tech seal ▶

Victor 2000 nonasbestos gasket material has a five-layer design with an outer coating of Teflon to seal surface irregularities, to take account of thermal expansion between faces, and to ease removal. Victor Division of Dana Corp., Box 455, Toledo, Ohio 43692-0455.



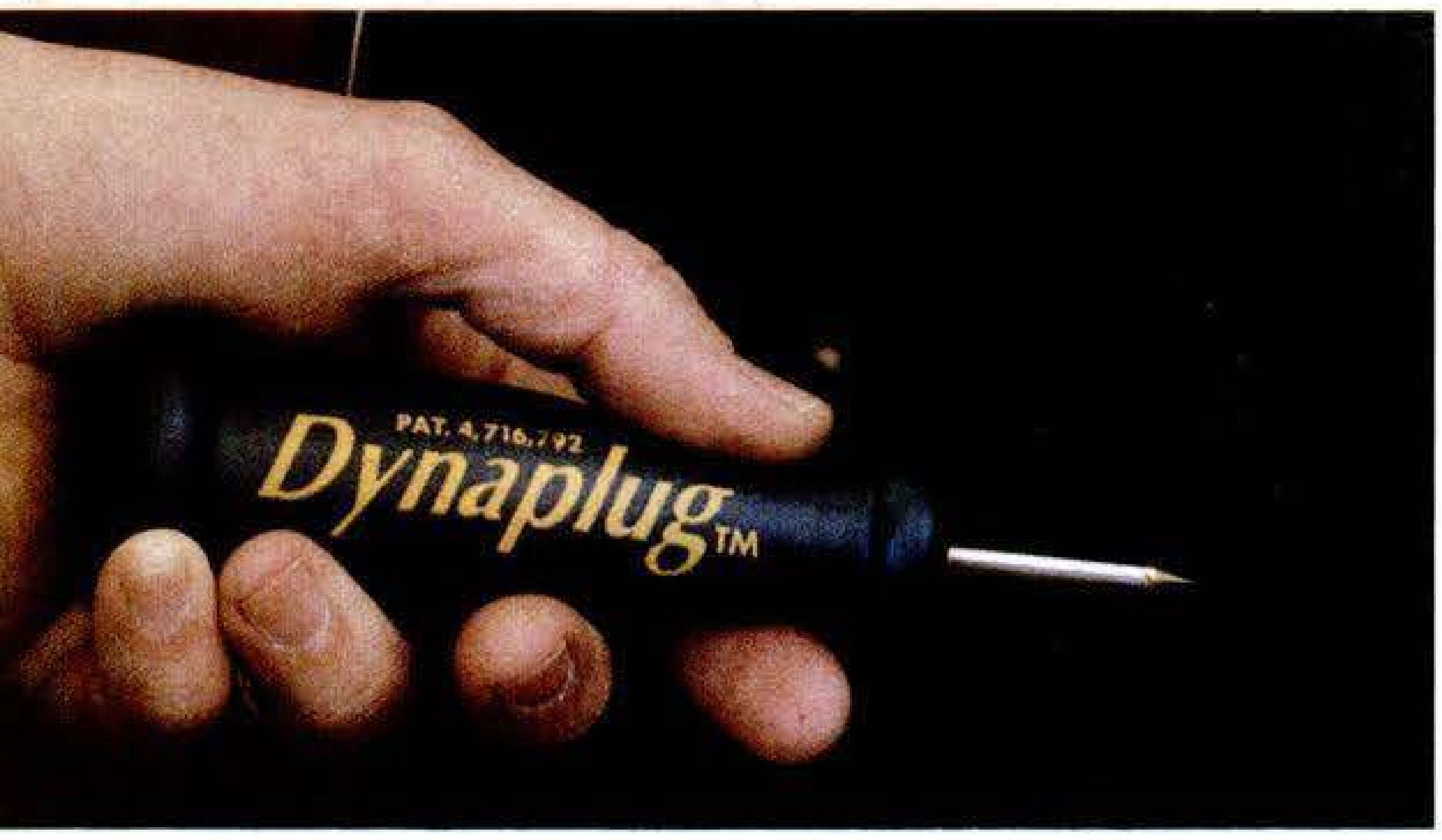
Power vacuum for cars ▲

The rotating power brush of the CarVac vacuum loosens trapped dirt and lint from upholstery and carpeting for a more thorough cleaning job, according to Black & Decker. The vacuum operates on the car's cigarette-lighter outlet and costs $40. Black & Decker, 10 N. Park Dr., Box 798, Hunt Valley, Md. 21030-0748.



◀ Safety box

Made of sturdy 11-gauge steel, Carsafe can keep registration and insurance papers or valuables, such as a cellular phone or tape deck, safely under lock and key. The model 5000 ($149) 12-by-12-by-3½-inch security box can be mounted under a seat or in the trunk with the included hardware. The model 2500 9½-by-11½-by-2⅞-inch box is $99. Colorado Carsafe, Box 440599, Aurora, Colo. 80044.



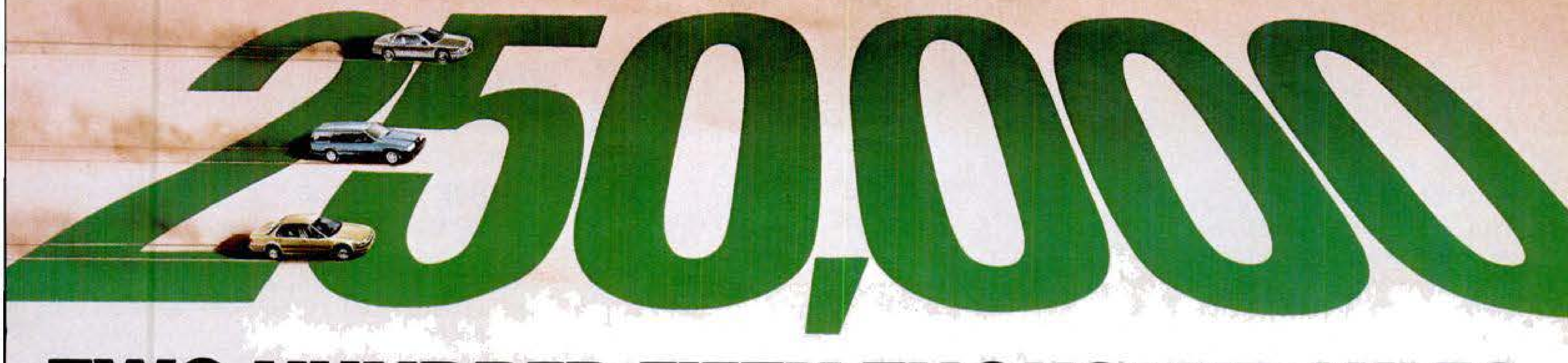
Tire repair, the easy way ▲

With Dynaplug you can quickly repair small punctures in most tubeless tires. Load the tool with a brass-tipped plug, insert it into the hole, and pull the handle out of the tire. The plug stays in place, providing a permanent repair. The plugs are made of a rubber-impregnated cord. Dynaplug is made by Hector Engineering Co. (1821 W. Third St., Bloomington, Ind. 47403) and sells for $10, complete with four plugs.

Power beam ▼

This rechargeable spotlight produces a 500,000-candlepower beam of light, 10 times brighter than an automotive headlight, for late-night roadside repairs. The RC-500K light will hold a charge for about 30 minutes of intermittent use and can be fully recharged in 24 hours. Including two rechargers and two colored filters, the spotlight sells for $80. Lectro Science, 6410 W. Ridge Rd., Erie, Pa. 16506.

ONE TOUGH MOTOR OIL ANNOUNCES ONE TOUGH GUARANTEE...



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Use Quaker State exclusively in your new car, and our limited guarantee will cover lubricated engine parts for 250,000 miles or ten years, whichever comes first.

How tough is today's Quaker State?

Tough enough to make this promise: Use only Quaker State in your new car's engine, and if any lubricated engine part not covered by the manufacturer's warranty or extended-service contract suffers an oil-related breakdown during its first 250,000 miles or ten years, Quaker State will pay for the repair.

We'll guarantee lubricated parts in engines of all sizes—domestic or imported.

Quaker State's limited guarantee covers lubricated parts in engines of every single imported and domestic car or light truck sold in the United States. It even covers the deductible on any extended warranty you might have purchased from your new-car dealer. Enrollment is absolutely free.

See a copy of lubrication limited warranty and enrollment details at participating service centers.

Complete details and enrollment forms for the Quaker State 250,000-mile or ten-year guarantee are available at participating Quaker State service centers. These include many new-car dealers, automotive service centers and fast lubes nationwide.

To participate in the guarantee program, enroll your new car at a participating service center within six months or 6,000 miles of purchase. Use only Quaker State Motor Oil, and have your oil and filter changed at a service center according to manufacturer's instructions for severe driving conditions but not to exceed 4,000 miles or four months between changes. Save your receipts.

How can Quaker State make a guarantee this tough?

Today's Quaker State has proven its toughness over and over again in the most rigorous tests that the world's auto makers have thrown at it. The result: Quaker State actually exceeds lubrication specifications for every single car sold in the United States. It takes a tough oil to offer a guarantee this tough. But Quaker State is One Tough Motor Oil.

Quaker State®

The Big Q is One Tough Motor Oil.

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DON'T POLLUTE. PLEASE DISPOSE OF USED MOTOR OIL PROPERLY.

BY MARCELLE M. SOVIERO

What's New RECREATION

A new handle ▶

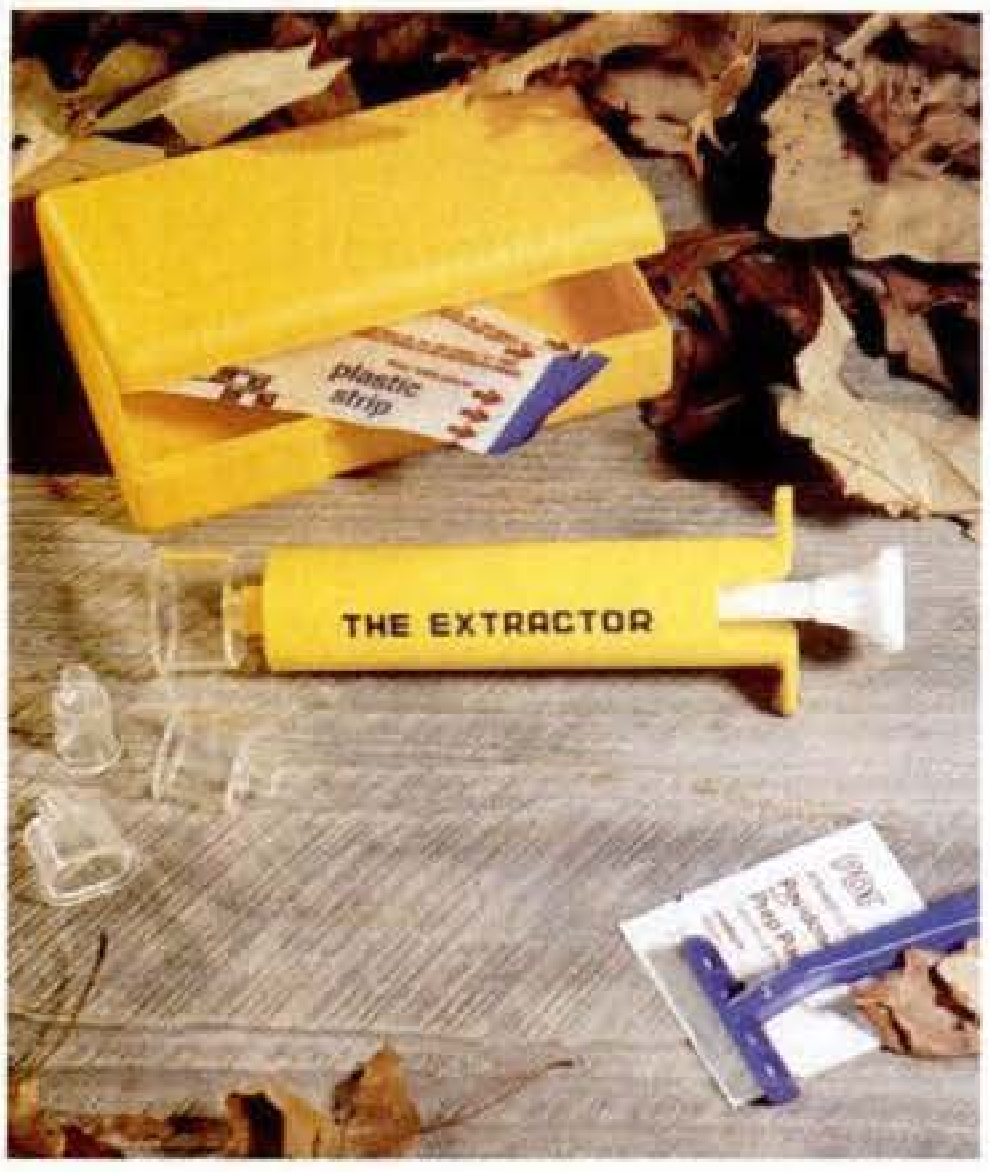
Frustrated with your forehand? A racket with a six-sided handle instead of the traditional eight might be the answer. The six-sider helps position your hand in exact alignment with the face of the racket, claims Andrew Brown, the inventor. This positioning gives you more control over each swing, says Brown. Research at the University of Massachusetts at Amherst showed a 14 percent improvement in forehand swings and a nine percent improvement in backhand swings with the six-sided handle. A major manufacturer will offer the $150 racket in August.

Cooler heads ▲

The Le Mond Air Attack helmet from Giro Sport Design was created for cyclists who need to keep a cool head during extended rides. Nine almond-shaped vents on the top of the helmet allow for 18.7 inches of air space. This ventilation system is designed to cool your head without causing additional drag on the helmet. A layer of polystyrene reinforces the foam liner, which is standard in all safety-approved helmets, and makes the helmet durable, claims Giro. Price: $90.

Safety shades ▶

Need protection from the sun while you're on the slopes or out at sea? These SAS 4000 sunglasses feature a no-slip nose grip that keeps them secure during all action sports, says Swiss Army Brands. Polycarbonate plastic lenses provide 100 percent protection from ultraviolet rays and are less than half the weight of glass. Price: $115.



Snakebite protection ▲

Planning a hike in the woods? You might want to bring The Extractor. It's designed to remove venom and poison from insect stings and bites. Just attach one of the plastic cups that best covers the bitten area to the pump and push the plunger to extract the poison. Sawyer Products, Box 188, Safety Harbor, Fla. 34695.

◀Composite clubs

You may want to put down your irons and woods and try improving your golf game with composite clubs. Composite materials provide the strength of steel with only one-third the weight. In golf terms, this means you have ideal weight distribution in the club and a solid feel in the swing, claims Yamaha Corp. (6600 Orangethorpe Ave., Box 6600, Buena Park, Calif. 90622).

BY TIMOTHY O. BAKKE

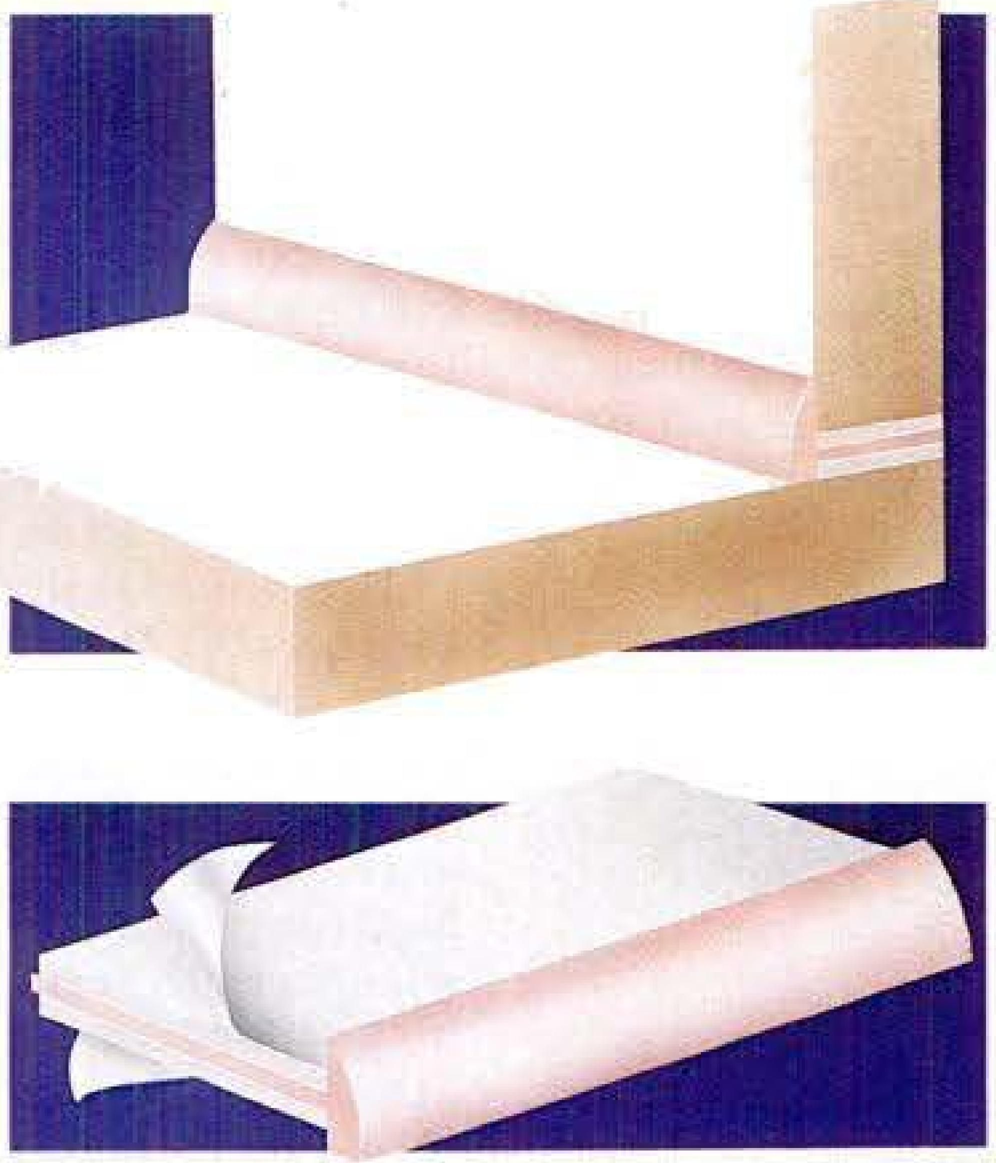
What's New HOME

High-R fiberglass ▲

In response to higher insulation values recommended by the Model Energy Code, manufacturers have developed higher-density fiberglass insulation that yields R-15 versus R-11 for 3½-inch batts and R-21 versus R-19 for 5½-inch batts. Owens-Corning Fiberglas Corp., Fiberglas Tower, Toledo, Ohio 43659; CertainTeed Corp., Box 860, Valley Forge, Pa. 19482.

Out-of-the-kitchen grill ▶

The Lanai Outdoor Grill is the first 240-volt electric grill listed by Underwriters Laboratories for outdoor use. Intended for a covered area like a porch, veranda, gazebo, terrace, or deck, the down-drafted grill is designed to be installed in a worktable or counter. Jenn-Air Co., 3035 Shadeland, Indianapolis, Ind. 46226-0901.

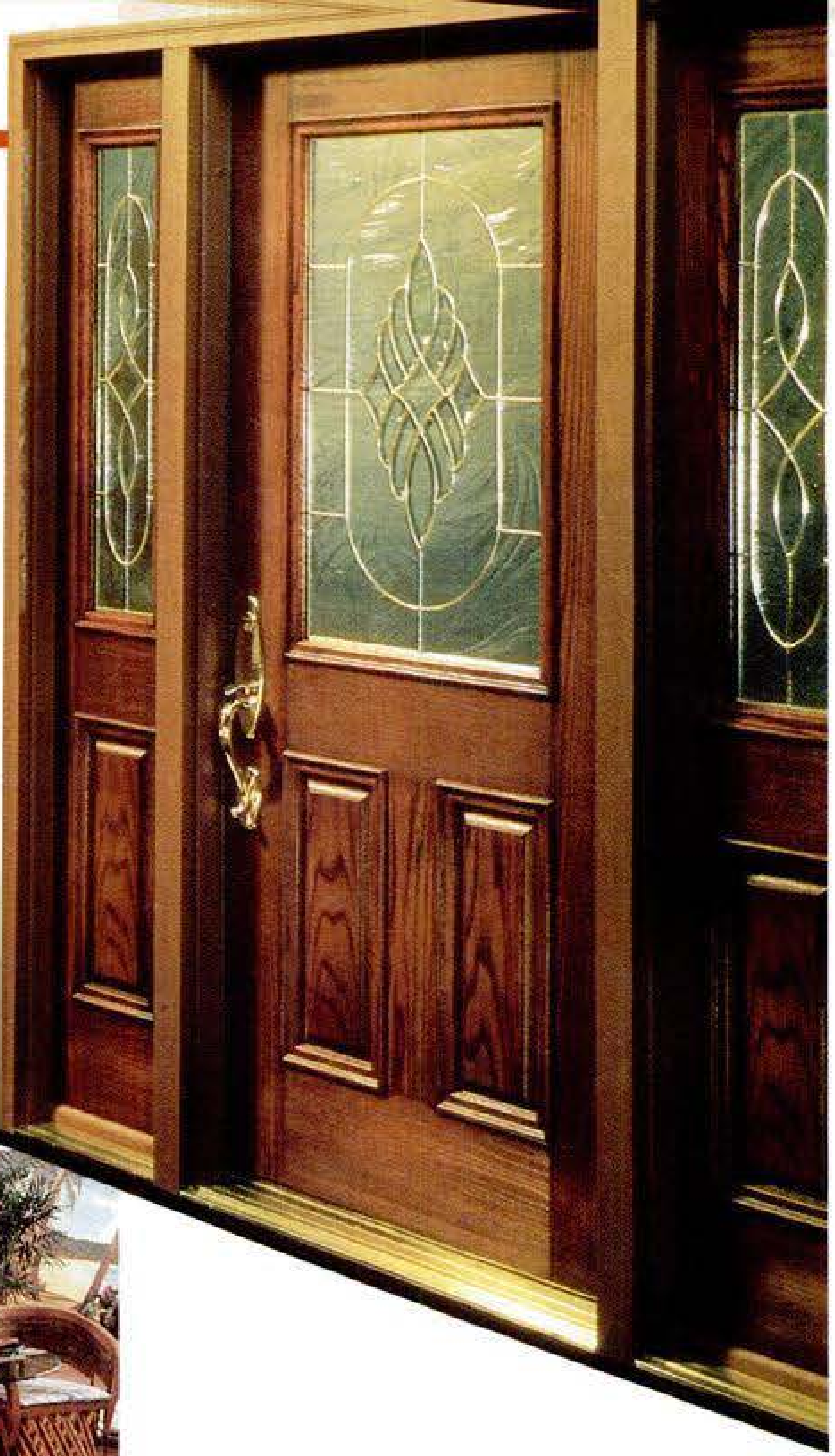


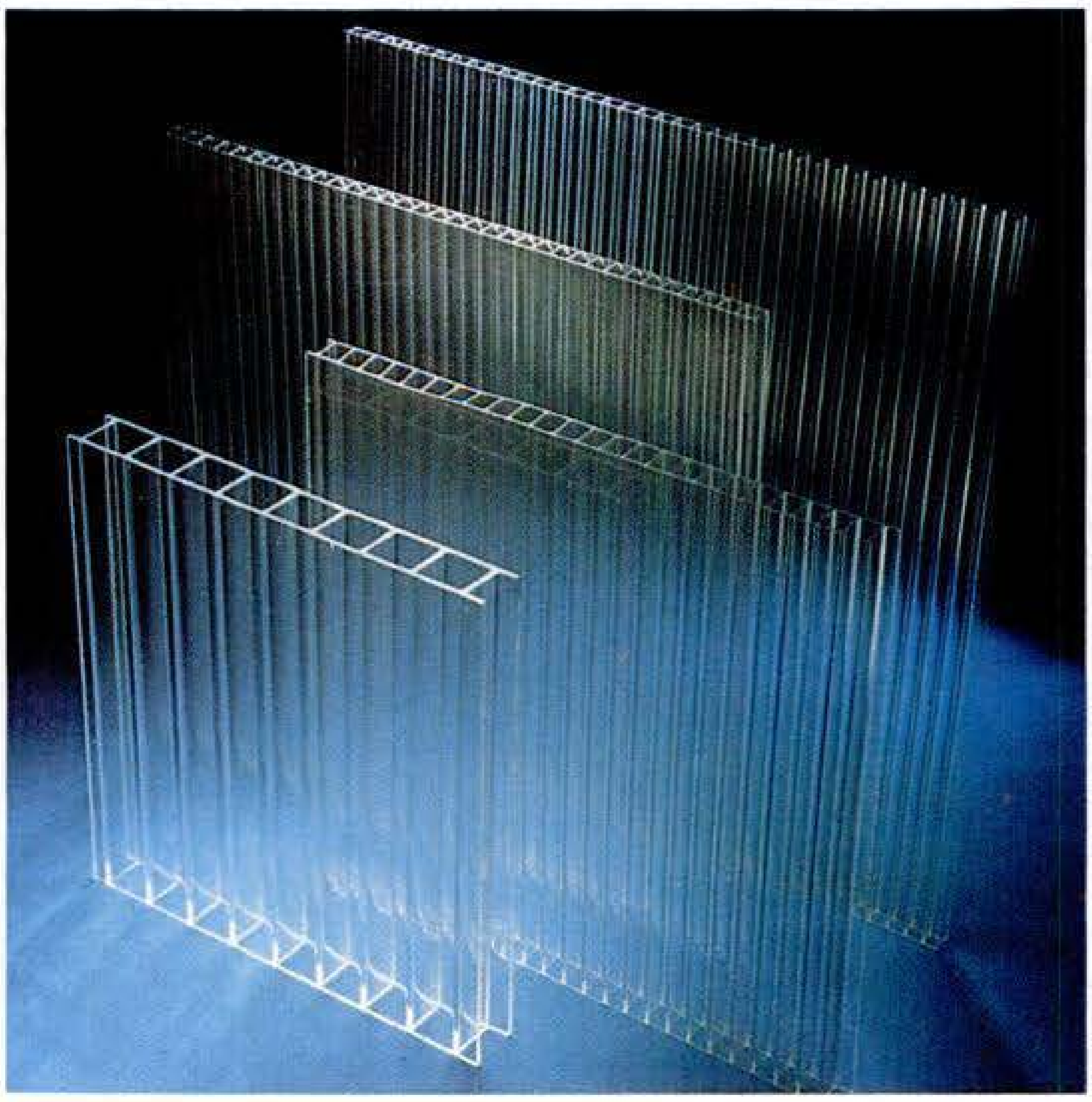
Counter-top sealer ▲

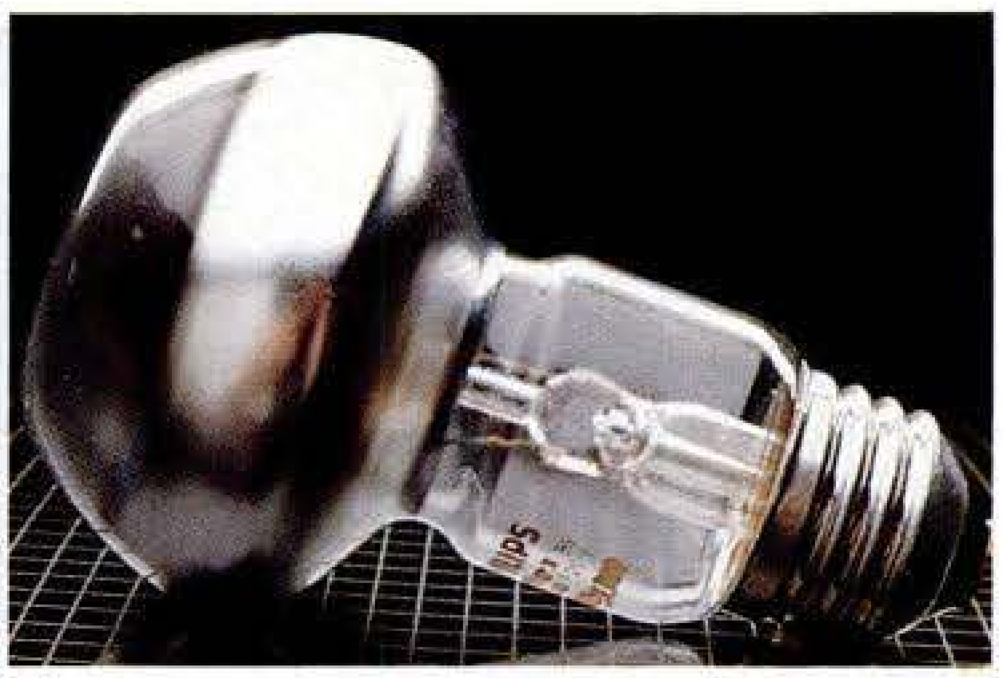
Pull the protective paper from Colorseal's adhesive strips (above), assemble the counter top and back splash around the PVC seal (top), and you have a no-seam joint without caulking, says Flexible Materials (11209 Electron Dr., Louisville, Ky. 40299).

No, it's not wood ▶

Ever-Strait insulated fiberglass doors look remarkably like authentic wood ones in part because they feature raised panels, unlike any other composite door on the market, says Pease Industries (Fairfield, Ohio 45014). The doors also have a porous surface that can be stained like wood, as well as a subtle embossing that resembles true wood grain. Patented bimetal brass and steel edge stripping surrounds the doors, enabling the use of magnetic weather stripping to seal against air infiltration. Prices: $425 to $1,100.







Super spot ▲

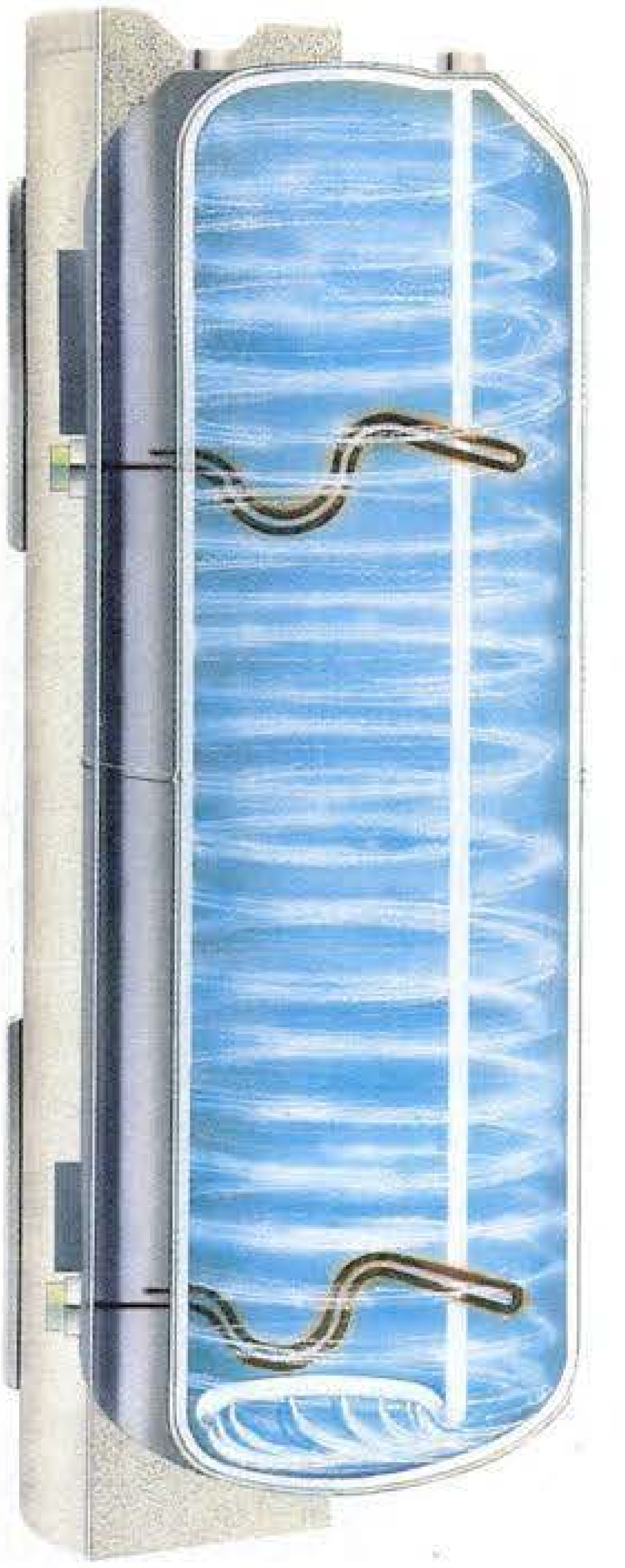
Spotline is a computer-designed reflector lamp with an unusual shape that provides 100 percent more light on the task area than conventional reflector lamps, claims Philips Lighting Co. (Box 6800, Somerset, N.J. 08875).

◀ Strong plastic

Two walls give Lexan Thermoclear extra strength and insulation capability: It's 250 times more impact resistant and 40 percent more energy efficient than ¼-inch glass. General Electric Co., Pittsfield, Mass. 01201.

BY TIMOTHY O. BAKKE

What's New HOME



No-leak water heater ▲

The seamless composite lining in the Duron electric water heaters lasts twice as long as glass linings and doesn't require an anode, which may produce sulfurous odors, says State Industries (Ashland City, Tenn. 37015). Also, the water-inlet coil produces turbulence in the tank to prevent sediment buildup, claims State. Price: $150 to $300 (30 to 82 gallons).

Rainproof roof vent ▲

The flexible RidgeMaster vent lets hot air and moisture exit the roof peak, while keeping insects and wind-driven precipitation out, through an unusual internal baffle-and-gasket design, claims Mid-America Building Products Corp. (9246 Hubbell Ave., Detroit, Mich. 48228). Price: about $3 per foot.

JOHN B. CARNETT

◄Simple valves

Uni-Ball hose bibbs, sill cocks, shut-offs, drain faucets, and stop-and-waste valves couldn't be much simpler: The washerless design comprises just four parts—body, ball-and-handle, O-ring, and retaining ring. Made of forged brass and able to withstand pressures of 200 psi, Uni-Ball is the first line of household valves to use ball-valve design, says B & K Industries (655 Wheat Lane, Wood Dale, Ill. 60191).

JOHN B. CARNETT

◄Convertible iron

For ironing jobs where the cord always seems to be in the way, you can use the Rowenta Mode 2 cordless iron. For heavy pressing jobs where you need more heat for longer times than a cordless can provide, you can also use the Mode 2. The 1,200-watt steam iron is the first that can be used with or without the cord attached, according to Rowenta Inc. (281 Albany St., Cambridge, Mass. 02139). Price: $110.

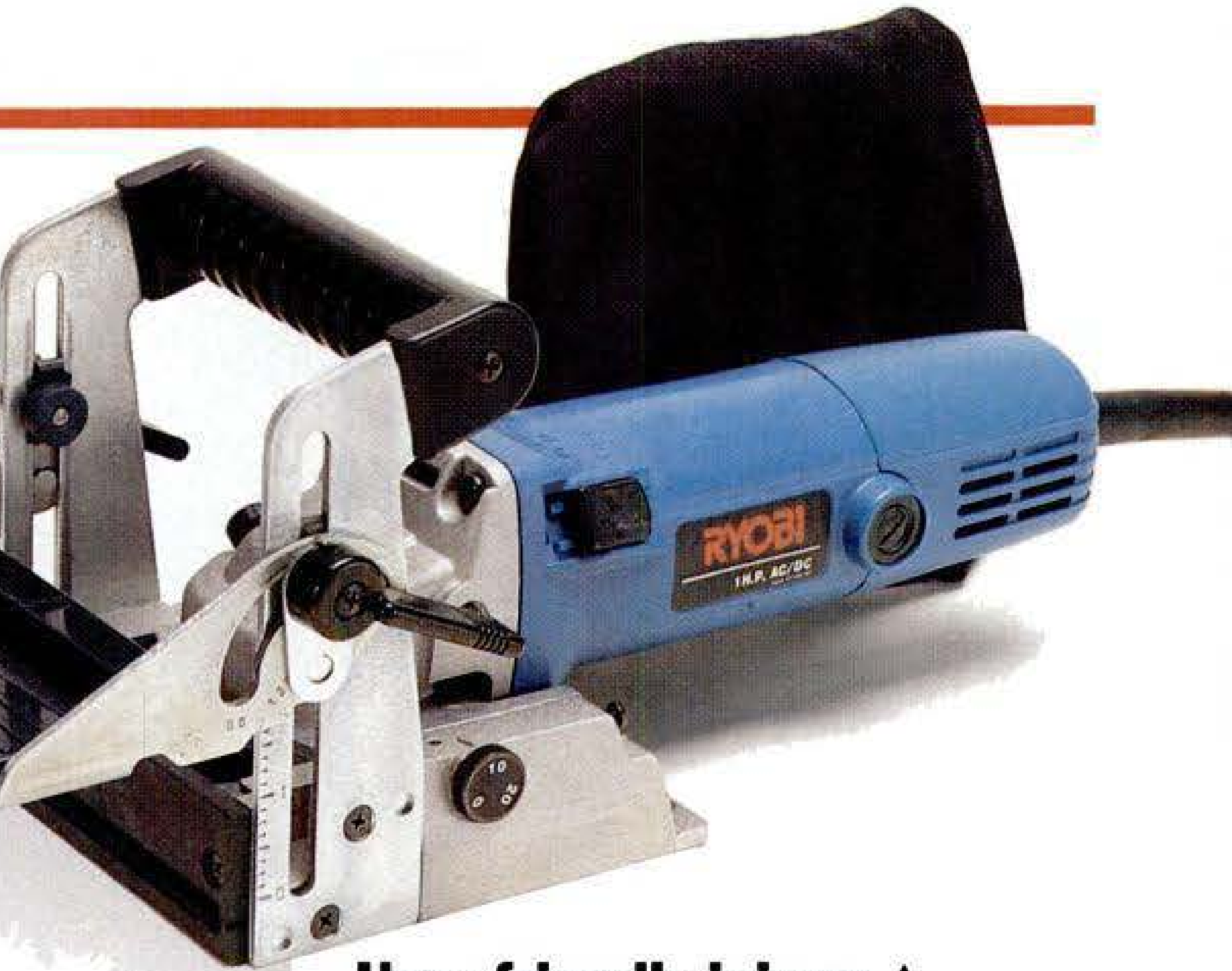
High-strength faucet ▼

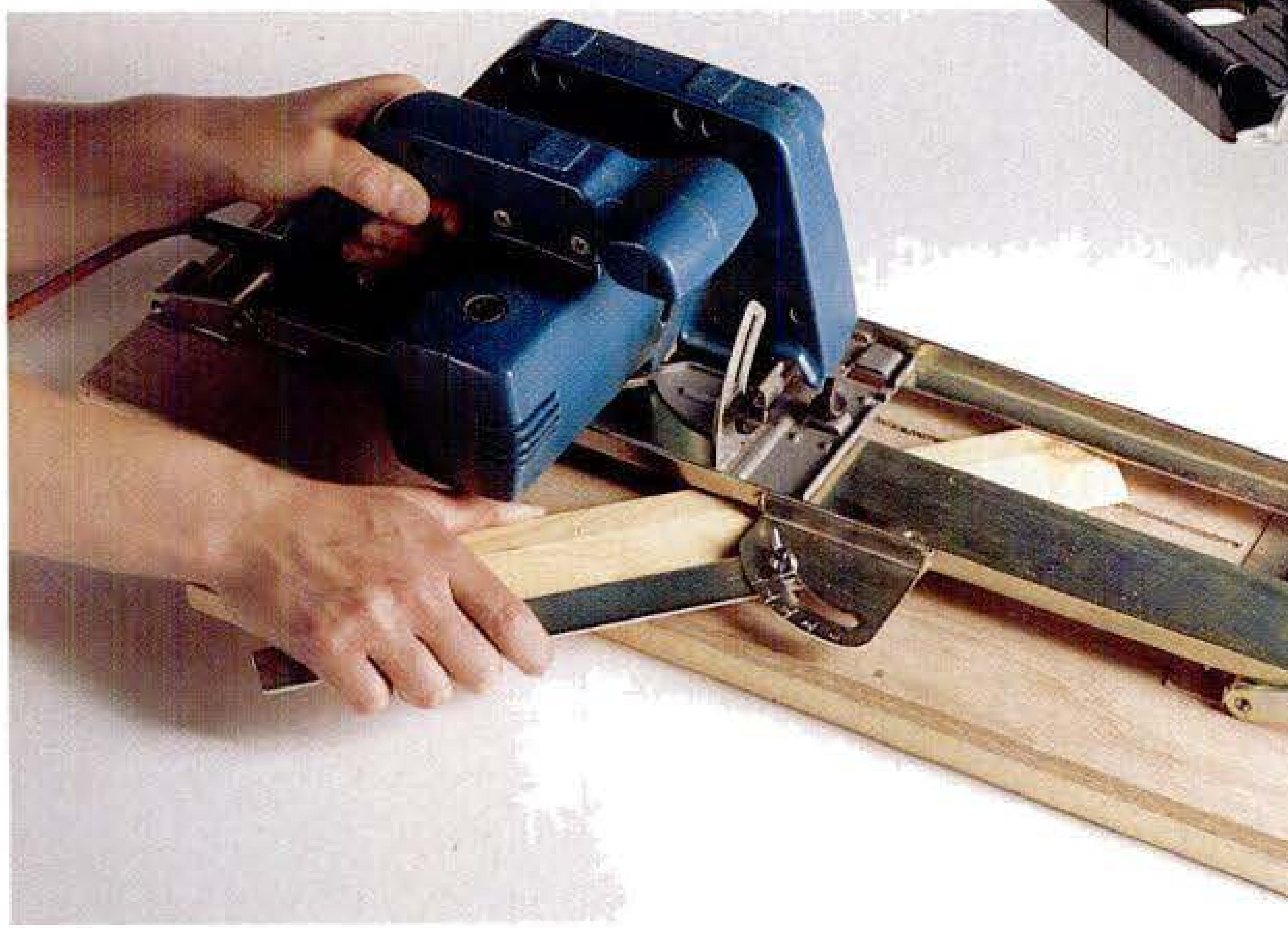
Durapro polypropylene faucet cores resist harsh chemicals and corrosive mineral buildup better than those made of metal, and can withstand 2,500-psi bursts of hydrostatic pressure, says Nibco Inc. (Box 1167, Elkhart, Ind. 46515-1167). Durapro also can be installed like metal without fear of cracking under high torque: In tensile-strength tests it outperformed other plumbing resins by as much as 3,000 psi, according to Nibco. Durapro is available in kitchen and lavatory faucets.

JOHN B. CARNETT

BY CHERYL M. FIORILLO

What's New TOOLS





User-friendly joiner ▲

Ryobi's JM-100K biscuit joiner was designed for convenience, says the company. Biscuit joiners cut oval slots into which you glue a mating spline (a biscuit), forming a strong, almost foolproof joint. The new Ryobi joiner has a dial to set the depth of cut for the three standard biscuit sizes; a fence with positive stops for bevel cuts at 45, 90, and 135 degrees; and a dust bag that minimizes the mess. List price: $230. Ryobi America Corp., 1424 Pearman Dairy Rd., Anderson, S.C. 29625.

Portable angler ▲

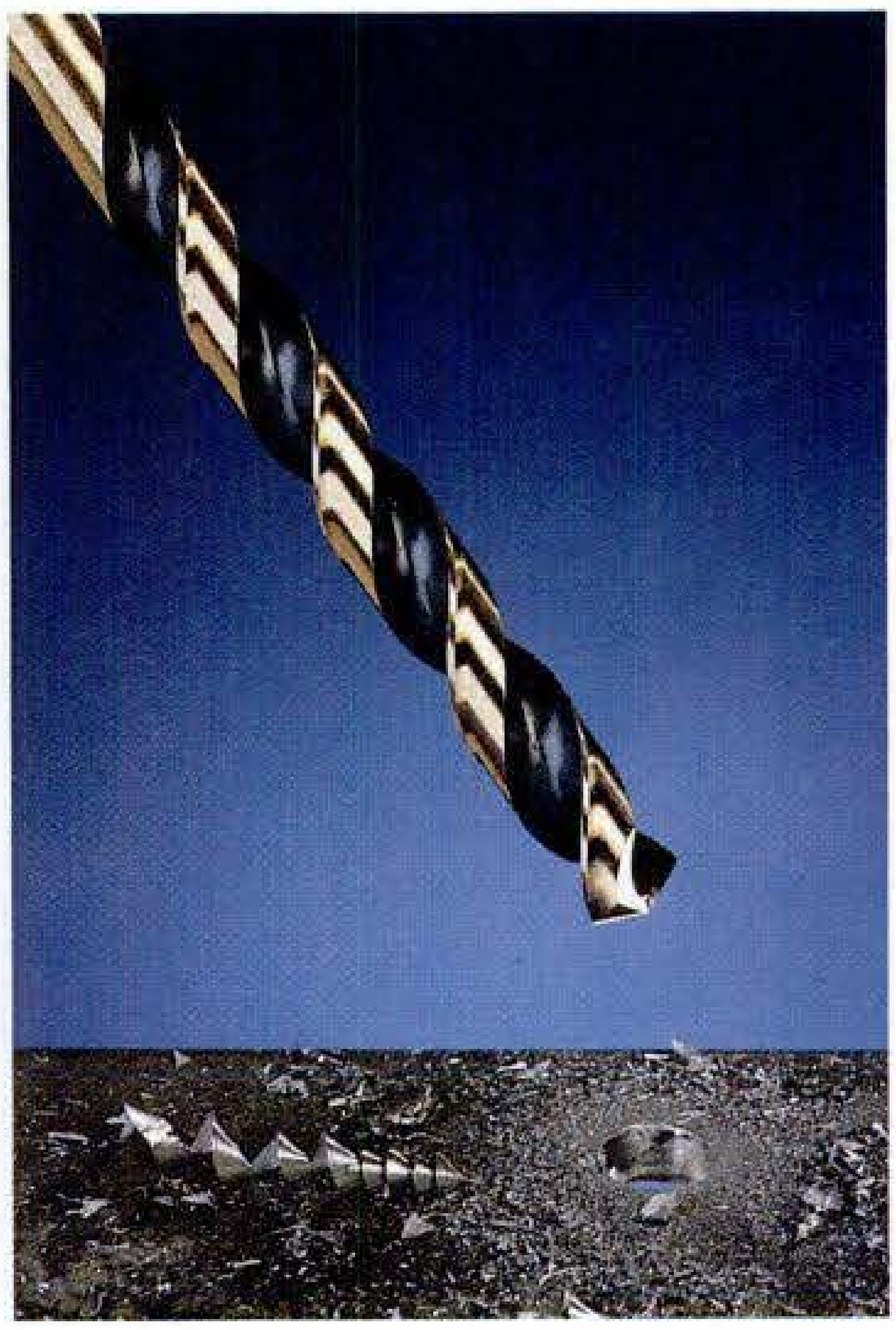
A simple jig called Miterite aligns your power saw with your workpiece for perfect miters, bevels, even compound angles. The saw's base plate slides on two guide rails, which are linked to the wooden base with connectors that pivot to accommodate the work. Frenway Supplies, 11 Keats Close, Newport Pagnell, Bucks MK11 8DW, England.

Cordless glue gun ▶

The Thermogrip butane-powered cordless glue gun heats up in four to five minutes to bond wood, leather, ceramic, plastic, paper, and more. A disposable butane cartridge provides four hours of gluing time. This $30 gun comes with two all-purpose glue sticks and one Thermacell butane cartridge. Replacement cartridges are two for $6. Black & Decker, Box 798, Hunt Valley, Md. 21030-0748.

Tags for tools ▶

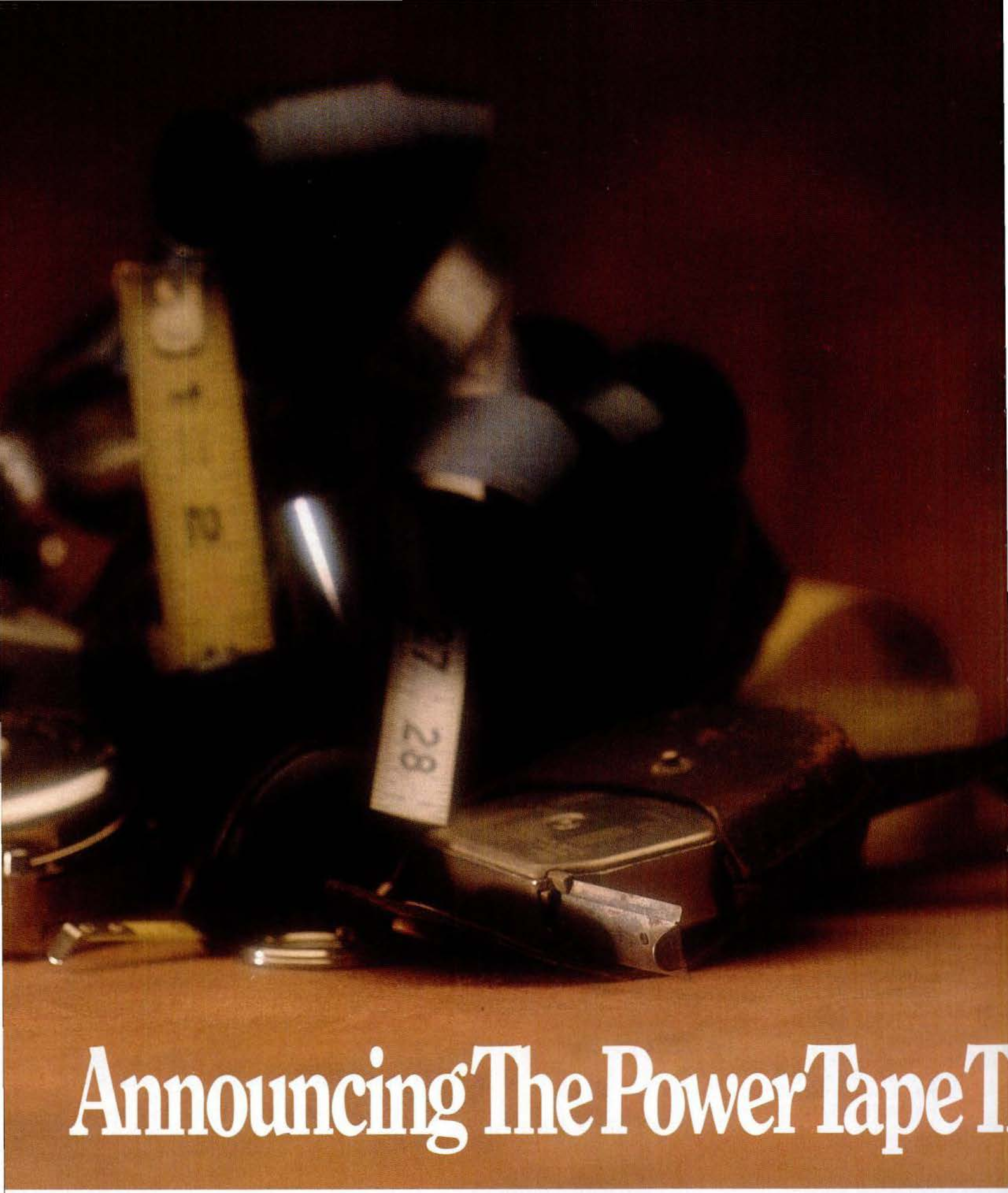
Bright red and white labels called Tool Tags identify wrench, socket, and nutdriver sizes at a glance and eliminate clumsy fumbling through your toolbox. The peel-and-place tags are available in English ($^3/_{16}$ inch to $^7/_8$ inch) and metric (4 millimeter to 19 millimeter) sizes. Price: $1.50 per sheet. Tool Tags Co., Box 329, Milwaukee, Wis. 53201.



Metal piercer ▲

The Sidewinder bit is designed especially for dry drilling into metal with a portable electric drill. But it is also fine for drilling plastic and wood. Its acutely angled point eliminates "walking" and speeds up cutting time, claims the manufacturer. And sharper spirals remove chips faster to extend bit life. The bits are sold individually (from $1.45 to $13) and in 7-, 10-, 13-, and 29-piece sets. Price of sets: $11 to $118. The largest set comes in a metal storage case; smaller sets are housed in plastic cases. Vermont American Tool Co., Box 340, Lincolnton, N.C. 28093-0340.

MONICA STEVENSON



We've seen a mountain of power tapes since we built the first one over fifty years ago. But this Lufkin® Series 2000 is the best yet.

This is because, while it's an entirely new design, we started with a few proven components. Like the guts of the tape.

After all, some parts just don't get any better.

Most everything else we improved. One you'll notice right away is the new blade, with its improved color, graphics, and virtually unbreakable end hook.

What we couldn't improve, we reinvented to look and work better. With the help, we should

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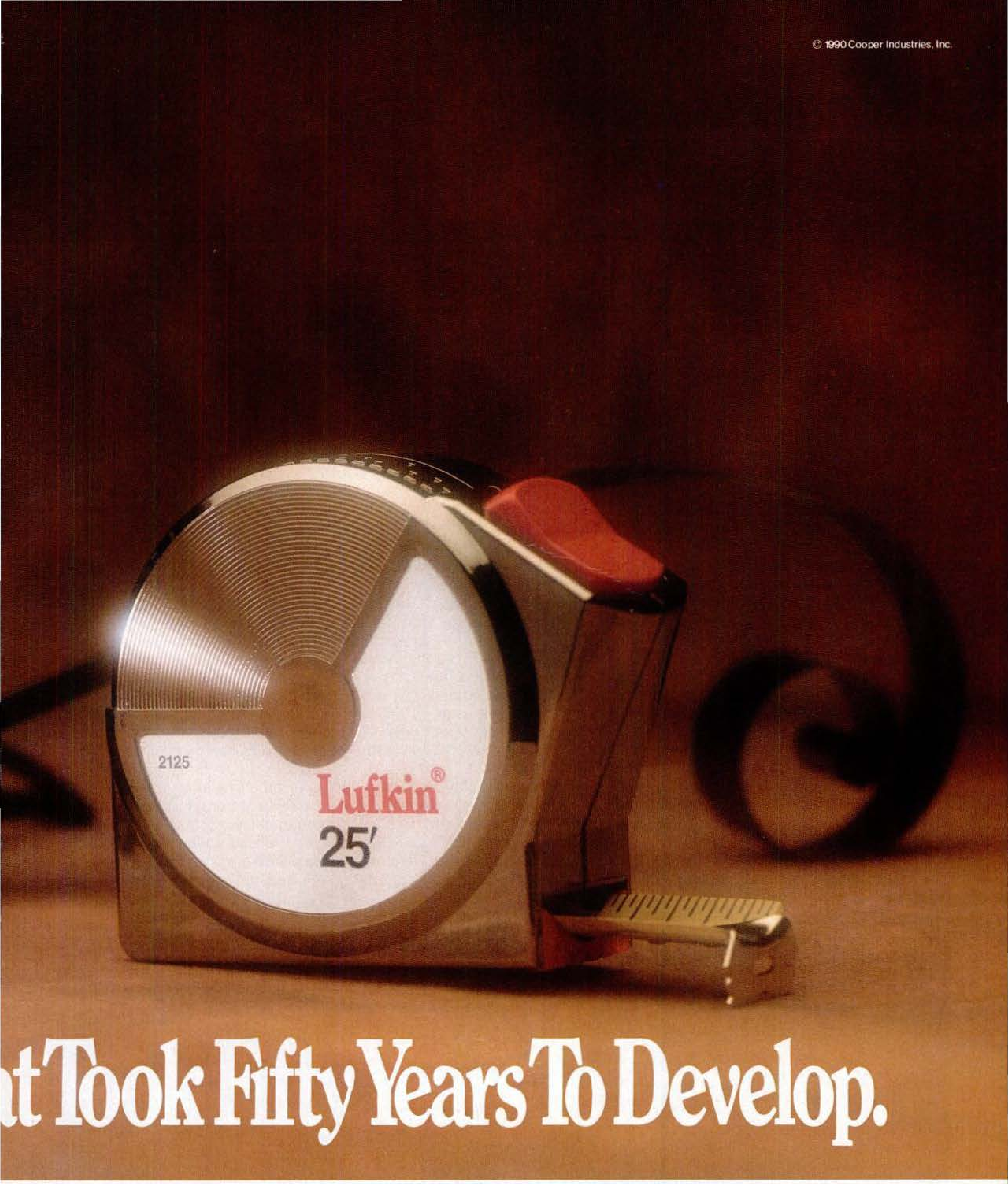


t Took Fifty Years To Develop.

add, of several hundred tradesmen from around the country who worked with the prototype and told us how to make it even better.

That's why the rounded case feels as if it's part of your hand.

And has the blade lock located on top, where your thumb says it should be.

So if you use a power tape, check out the new Series 2000. And the No Risk Trial Offer that comes with every one. It might be another fifty years before you see anything that can touch it.

CooperTools
A DIVISION OF COOPER INDUSTRIES, INC.

Science Newsfront

By ARTHUR FISHER

Far from the madding crowd

That's our galaxy you're looking at, the storied Milky Way. It's hardly visible in the night sky anymore, at least to dwellers of cities, suburbs, and exurbs, because of ever-encroaching light pollution.

But astronomers have been able to obtain images of the galaxy from space. These edge-on views show a flattened disc. The aspect is edge-on because our sun is part of the galaxy itself, and lies in the plane of the disc. It resides, along with its system of planets, far out on one of the Milky Way's spiral arms, about 28,000 light-years from the galaxy's center.

The astonishing thing about this picture is that it shows, for the first time, something of the teeming, glowing bulge of stars that lies close to the galaxy's center. Before now, this region, which some astronomers think conceals a massive black hole, was obscured by clouds of interstellar dust that strongly absorbed visible wavelengths of light, with which earlier photos were made.

Now, however, NASA's Cosmic Background Explorer (COBE) satellite has penetrated the dust veil by imaging the galaxy in three different infrared wavelengths: 1.2, 2.2, and 3.4 microns. The photo below combines the three images as blue, green, and red, respectively. The image is redder where there is more dust between the stars absorbing more light and then reradiating it as longer-wavelength infrared.

The COBE satellite made the images from an orbit about 560 miles above Earth. It was launched last November to study the coldly ethereal cosmic background radiation that is the residue of the big bang—the primal scream of energy that astrophysicists believe gave birth to the universe 15 to 20 billion years ago. This first penetrating glimpse of our galaxy, said Michael G. Hauser, chief astronomer of NASA's Goddard Space Flight Center, was a "fringe benefit" of COBE's primary mission.

Oats in your ice cream?

Claims for the health benefits of various grains—oats, rice, barley—have turned into a kind of cereal derby that can make your head spin. More fiber was added to the fire at an American Chemical Society meeting in Boston last April, when one scientist proposed a method of making frozen desserts, salad dressings, sauces, and the like that were not only virtually fat free but had cholesterol-lowering properties.

Dr. George Inglett of the U.S. Department of Agriculture said he and his colleagues have found a way to treat oat bran and flour to yield a tasteless gel that could replace fats in many products, especially lower-temperature ones.

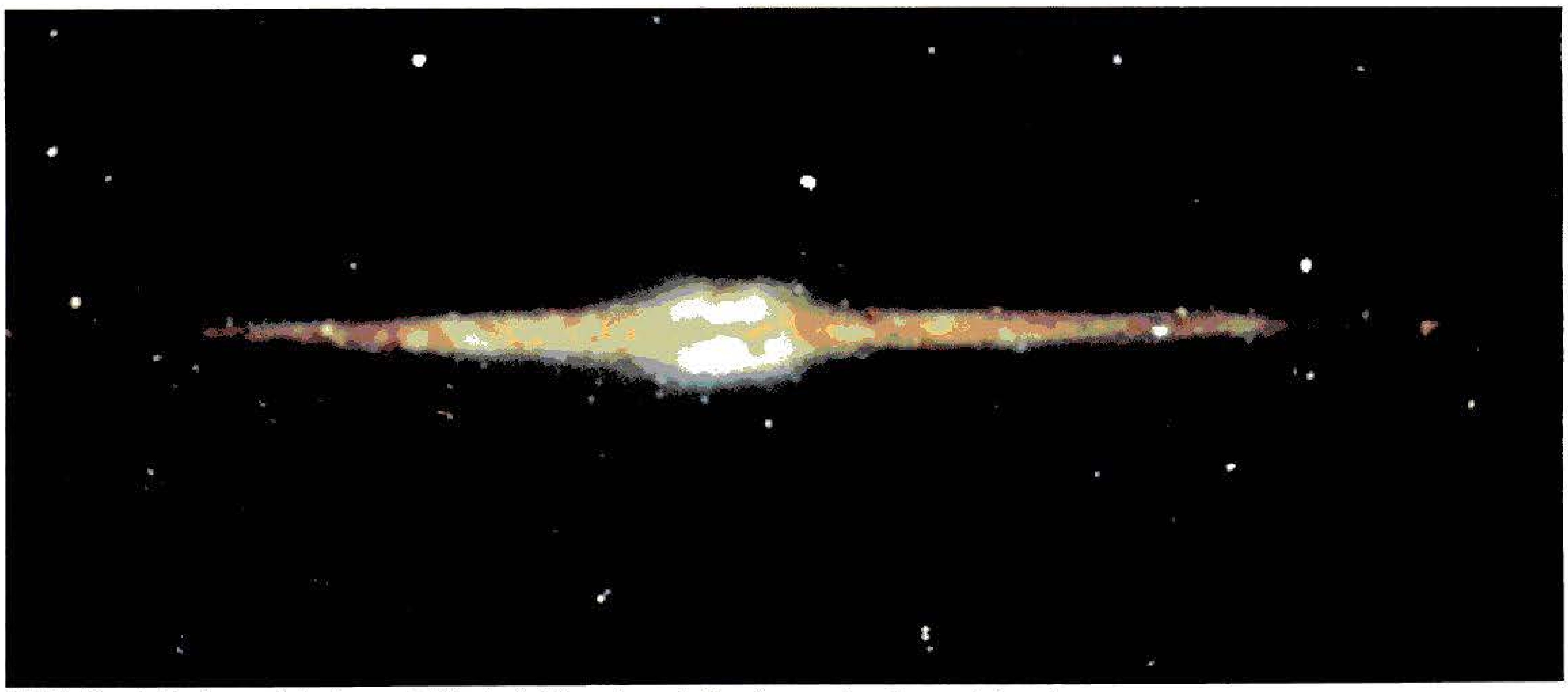
The product, for which patents are pending, is called Oatrim. It has only 10 percent of the calories of fats. "It can give cholesterol a double whammy," Inglett said, because it can not only replace saturated fats, which raise cholesterol levels, but it also contains a significant amount of beta-glucan, a soluble fiber that has been shown to lower cholesterol.

For example, Inglett said, a four-ounce serving of premium ice cream contains between 18 and 22 grams of fat, 85 milligrams of cholesterol, and 250 to 300 calories. A similar-tasting "ice milk" made with the gel has almost no fat, a bare four milligrams of cholesterol, and a skinny 135 calories —mostly from the sweetener and skim milk.

To make the oat gel, Inglett treats oat bran and flour with enzymes called alpha-amylases. Under certain special conditions, the oat starch is converted into products called amylodextrins, which go into a solution along with the beta-glucan to yield a white gel that has no noticeable cereal flavor or grittiness, and supplies the smoothness essential to frozen desserts.

Also at the ACS meeting, Dr. James Anderson of the Veteran's Administration Medical Center in Lexington, Ky., explained that beta-glucan might operate to lower cholesterol by one or a combination of two mechanisms:

1) Beta-glucan may trap bile acids, the building blocks of cholesterol, and



NASA's Cosmic Background Explorer satellite took this unique photo of our galaxy in near-infrared.

This Blackbird's retirement flight ends with a record-breaking run to Dulles Airport near Washington, D.C.

cause them to be flushed out of the digestive tract.

2) Beta-glucan is broken down to short-train fatty acids in the large intestine and transported to the bloodstream. An excess of short-train fatty acids may decrease the liver's ability to produce cholesterol.

New mouse is good mouse

Dr. Gerhard Storch and his colleague Otfried Lütt of the Research Institute Senckenberg in Frankfurt, West Germany, have created a sensation among their fellow naturalists by reporting, in the "Zeitschrift für Saügetierkunde" (Journal of Mammal Science), their discovery of an absolutely new and unknown species of mouse. It is the Alpine wood mouse, *Apodemus alpicola*.

The co-discoverers reported that an essential element in recognizing the creature as a separate species was that it was found cohabiting in the same location as the yellow-necked mouse.

Just thought you'd like to know.

Sea-floor seismometer

For the next eight years, newly designed seismic monitoring equipment will patrol off the Southern California coast, gathering data that will help build earthquake-resistant offshore oil platforms.

The Seafloor Earthquake Measurement System, or SEMS, is diagrammed at right. A self-contained measuring unit receives and stores information from the sea floor using a probe, a microprocessor, and power from a battery pack. Then it transmits the data to a receiver aboard a surface vessel using an acoustic telemetry link.

The present version, SEMS III, is 50 times more powerful than its predecessors. Its improved seismic sensor, designed at Sandia National Laboratories, should pick up an average of five Southern California quakes per year with Richter-scale magnitudes of 3.0 or higher, says project leader Gerard Sleefe of Sandia's Advanced Technology Division.

"We had been dealing with a system that might get one or two earthquakes during its lifetime," says Sleefe. "That made for a costly system with a long-time turnaround in evaluating the response of offshore platforms to earthquakes."

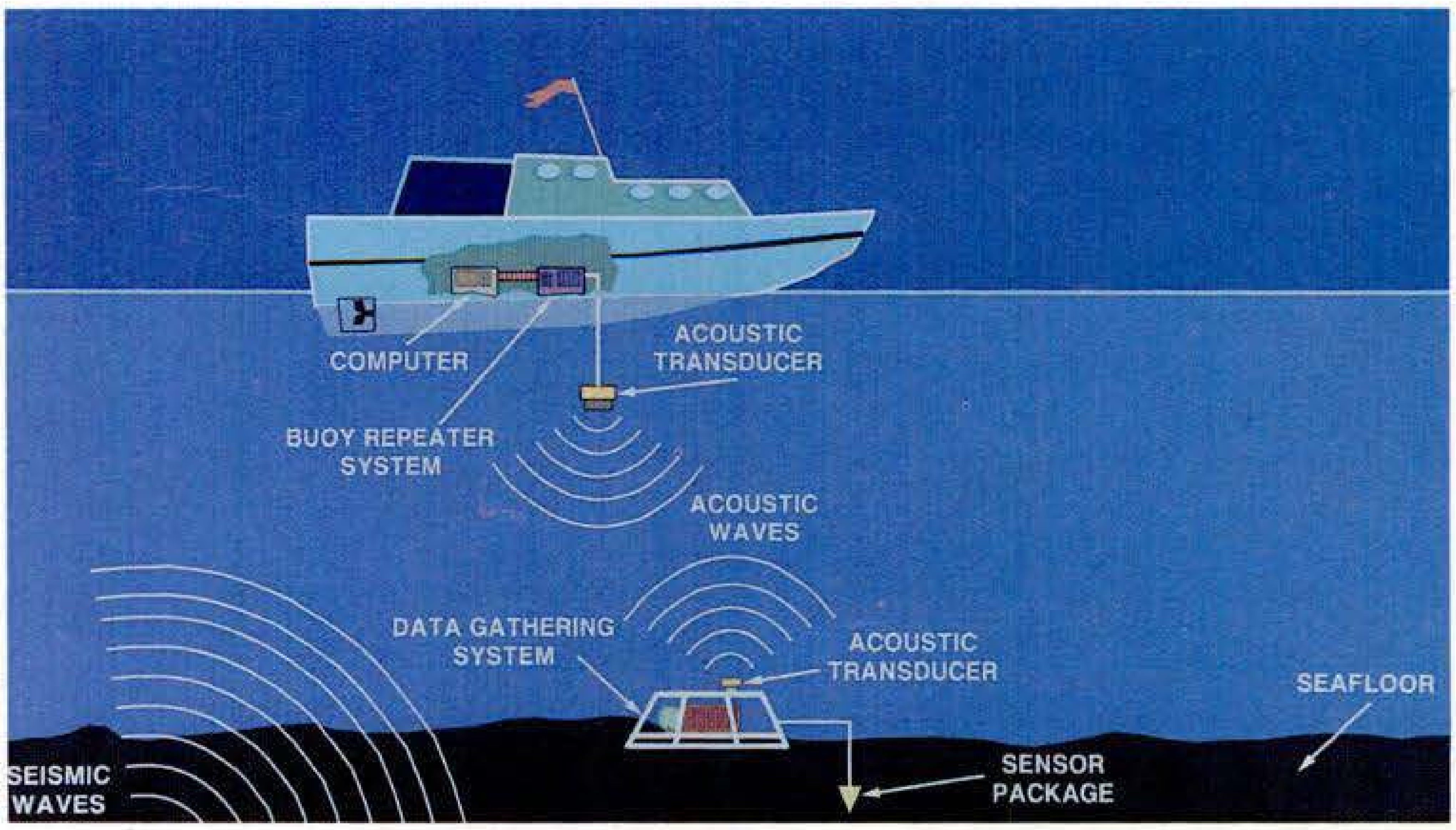
The eventual goal of the SEMS program, established in 1977, is to combine its results with land- and platform-based seismic sensors to give researchers a more complete picture of the behavior of offshore structures during quakes. Earlier versions of SEMS have indicated that seabed soils behave differently from dry land during a quake. Dry land shakes roughly equally in vertical and horizontal directions; the sea floor shakes primarily in a horizontal direction.

Blaze of glory for Blackbird

The plane whose sinister shape seemed the embodiment of the black art of spy craft has exited the world stage in a manner befitting its legendary and still secret service.

The Lockheed SR-71, better known as the Blackbird, blasted its way into aviation history by setting a coast-to-coast speed record for a transcontinental crossing. On March 6 it took off from a Mojave Desert airfield in California, was refueled over the Pacific, and then hurtled eastward. Just 68 minutes and 17 seconds later, it dove to 200 feet above the runway at Dulles International Airport outside Washington, D.C.

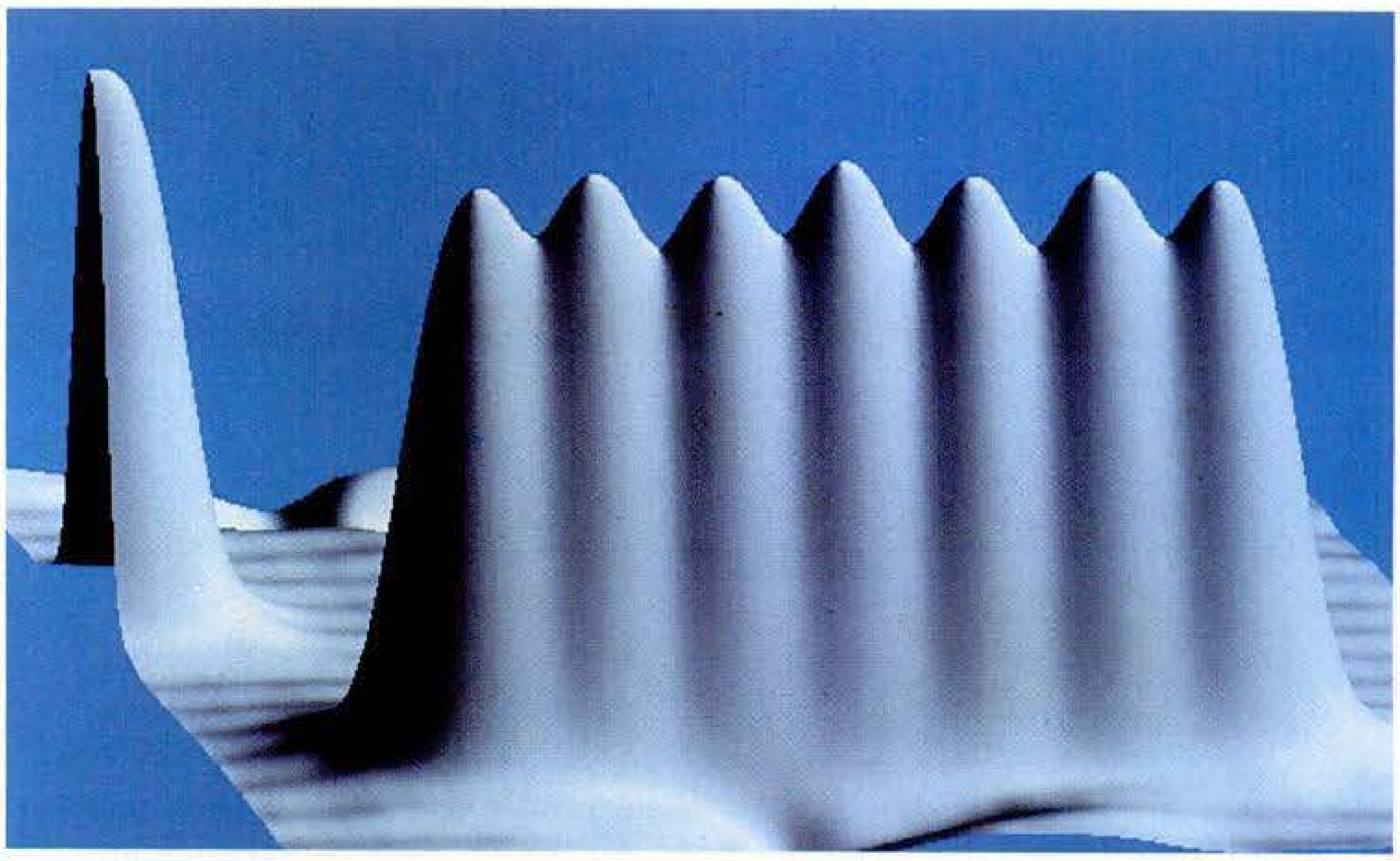
The new record humbled the previous one of 3 hours 38 minutes, set by an American Airlines Boeing 707 on a commercial flight from Los Angeles to New York in 1963. Its average speed was 680.9 mph. The Blackbird, the fastest and highest-flying production aircraft ever built, averaged 2,112.52 mph.



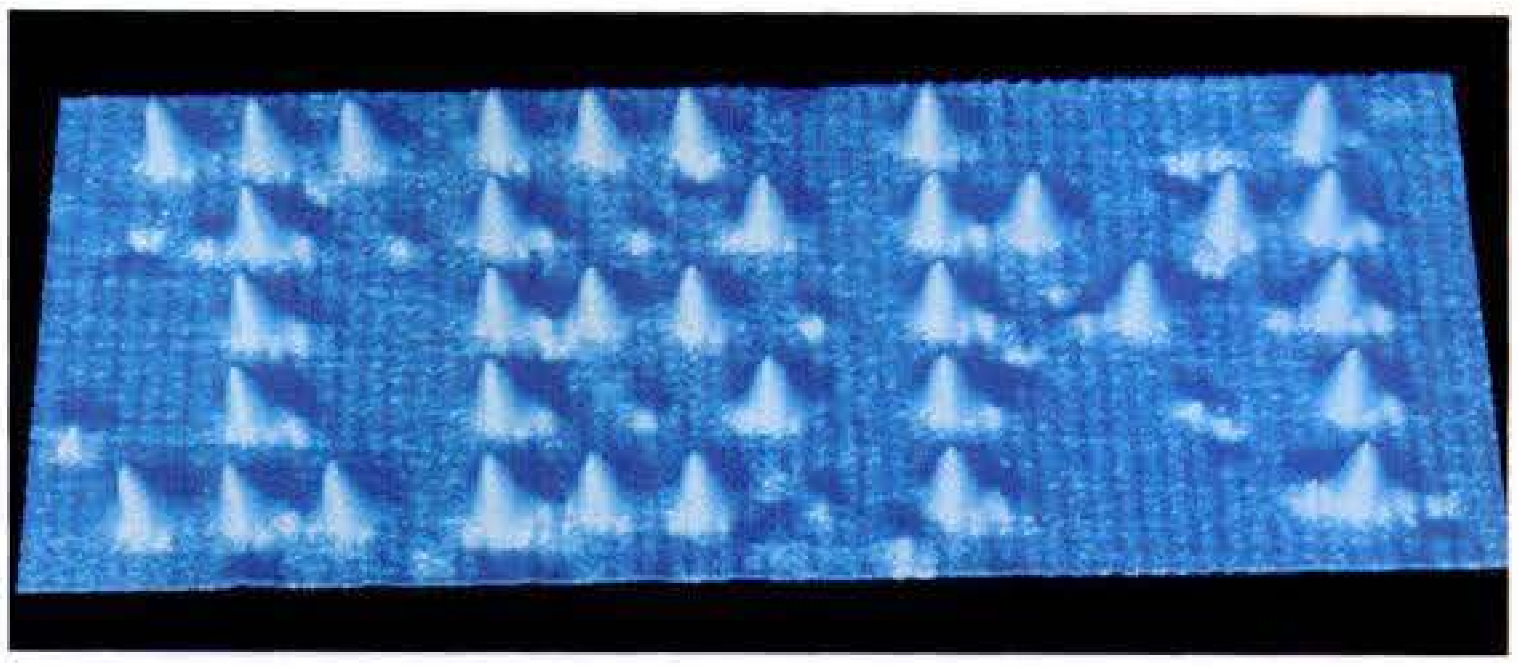
A new seismic system will help in the design of offshore drilling structures.

After 25 years of classified reconnaissance missions for the Air Force, all these Mach 3 aircraft will retire from active duty, replaced by super-secret satellites. The record-setting Blackbird, SR-71 No. 972, will perch in a Dulles Airport wing of the Smithsonian Institution's National Air and Space Museum. Eight other Blackbirds will be donated to museums, three will be used by NASA for research, and three will be mothballed at their home base in Palmdale, Calif.

Ben Rich, who helped design the Blackbird at Lockheed's famous "skunk works" in Burbank, Calif., echoed the ubiquitous calls of "bye-bye blackbird." "I cannot honestly say," he said, "that this is a happy day for me."



BERNIE BOSTON/LOS ANGELES TIMES



Xenon atoms are bound in the first man-made atomic cluster (top) and made to spell out "IBM."

Manipulating atoms

"One day we hope to reach the point where it is possible to manipulate individual atoms. . . ."

I used that statement, made by Stanford University physicist Calvin Quate in 1986, at the close of my article "Seeing Atoms" [April '89] on the scanning tunneling microscope, or STM, and its offspring.

The prediction has now come to pass—brilliantly. You can see the result in these STM pictures from IBM.

The larger picture shows the first man-made atomic cluster built one atom at a time—a chain of seven xenon atoms bound together. As reproduced here, the magnification is 22.2 million times. The xenon atoms are represented by the peaks. They are spaced 20 billionths of an inch apart and are just 6.4 billionths of an inch high. (The vertical scale is greatly exaggerated in this image.) The atoms were moved and imaged by IBM physicists Donald M. Eigler and Erhard K. Schweizer.

The smaller picture, at a magnification of 5.4 million times, shows an earlier triumph: the first successful attempt to move atoms into a recognizable pattern. Unsurprisingly, the pattern chosen first was "IBM," made up of xenon atoms. The overall length of the "IBM" is 600 billionths of an inch.

This remarkable achievement is the outcome of Eigler's wish to understand how atoms and molecules react with surfaces. In the process, he designed and built an STM capable of operating with unusual sensitivity and precision. Originally invented by two physicists at IBM's Zurich Research Laboratory (and for which they received a Nobel Prize), the STM can image individual atoms on a metal or semiconductor surface by scanning the tip of an extremely fine needle over the surface at a height of a bare few atomic diameters. Eigler and Schweizer discovered that if they moved the tip slightly closer to a xenon atom on the surface, they could drag the atom parallel to the surface. To fix the atom in a new position, they could simply raise the tip.

To accomplish this feat of legerdemain, the microscope must be kept in an ultrahigh vacuum and chilled with liquid helium to a temperature four degrees Kelvin above absolute zero. It must also be isolated from sound vibrations as feeble as a person's voice, and from heat sources as tepid as a human body. With these precautions, Eigler's STM can resolve vertical changes in an atom's apparent shape as small as eight trillionths of an inch, about 100 times smaller than an atom.

This achievement has fathomless implications. Among the wealth of potential applications: assembling custom-tailored molecules atom by atom; making crucial changes in individual molecules—to create new drugs, for example; making ultra-small electrical circuits far smaller than now possible; storing data on an atomic scale at densities more than a million times greater than achievable today; and even duplicating structures atom by atom, a possibility that should give every old-time science-fiction writer goose bumps.

"For decades," Eigler says, "the electronics industry has been facing the challenge of how to build smaller and smaller structures." Now, he says, the challenge will be to build those structures an atom at a time.

Another flash from Germany

Are you a Type A personality? Need to know the time, all the time, and to the split second? Do I have something for you. It's a true radio-controlled wristwatch. Not for calling Dick Tracy, but for receiving long-wave radio signals that emanate from the atomic clock at the Federal Institute for Physics and Technology in Braunschweig. The time signals are transmitted by a special antenna near Frankfurt and can be picked up anywhere within a range of about 1,000 miles. The watch, called the MEGA 1 and marketed by Junghans Uhren GmbH in Schramberg, picks up the signals with a flexible, highly sensitive aerial embedded in its leather strap. And a microprocessor keys the latest time signal into a memory so the watch doesn't lose the correct time when it leaves the transmission range.

Oh, I forgot to tell you how accurate this system is. The maximum error is one second in a million years.

When they say *punkt,* they mean *punkt.*

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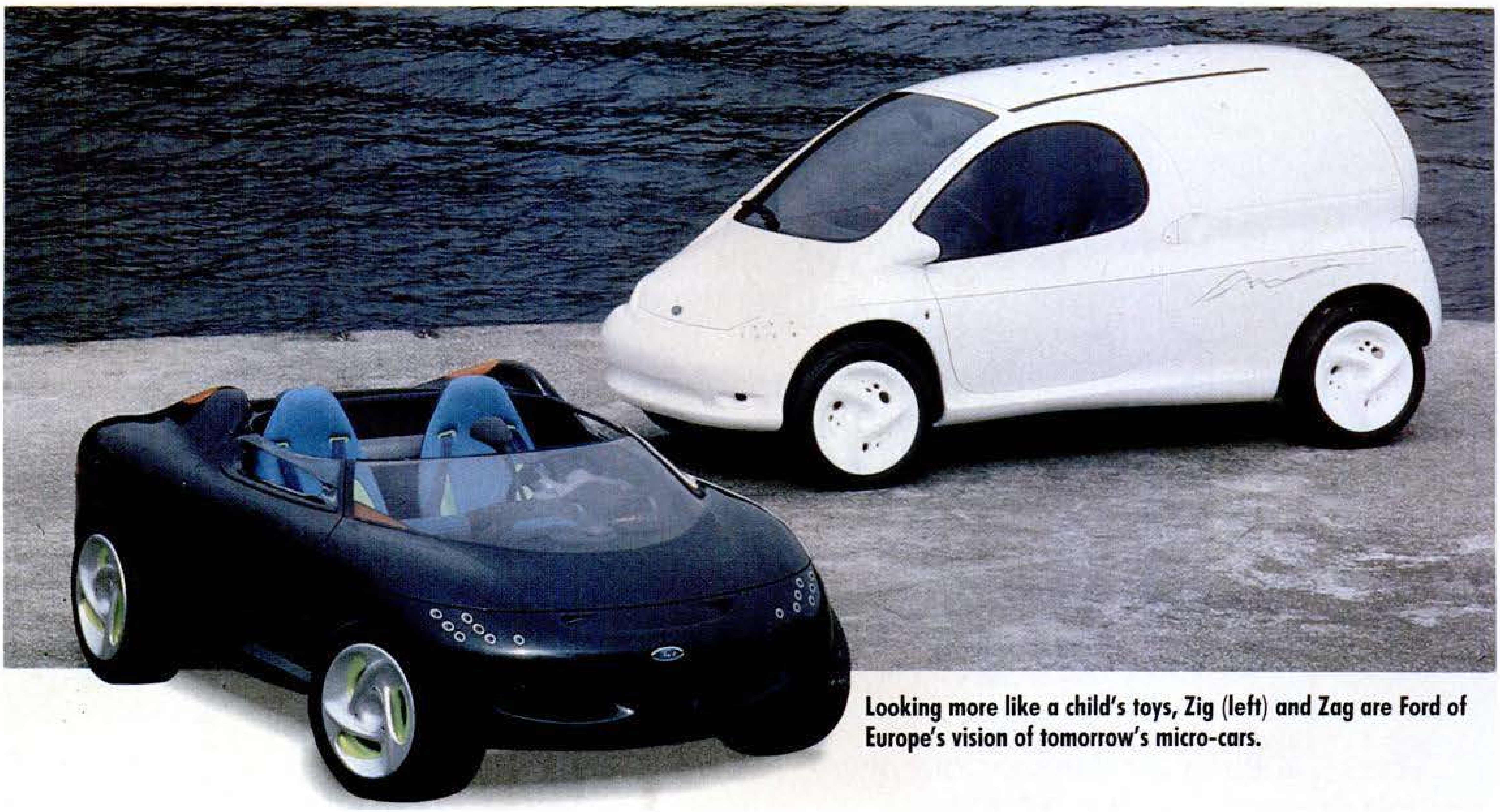
Automotive Newsfront

By DAN McCOSH Detroit Editor *with Dennis Normile in Japan and David Scott in London*



Looking more like a child's toys, Zig (left) and Zag are Ford of Europe's vision of tomorrow's micro-cars.

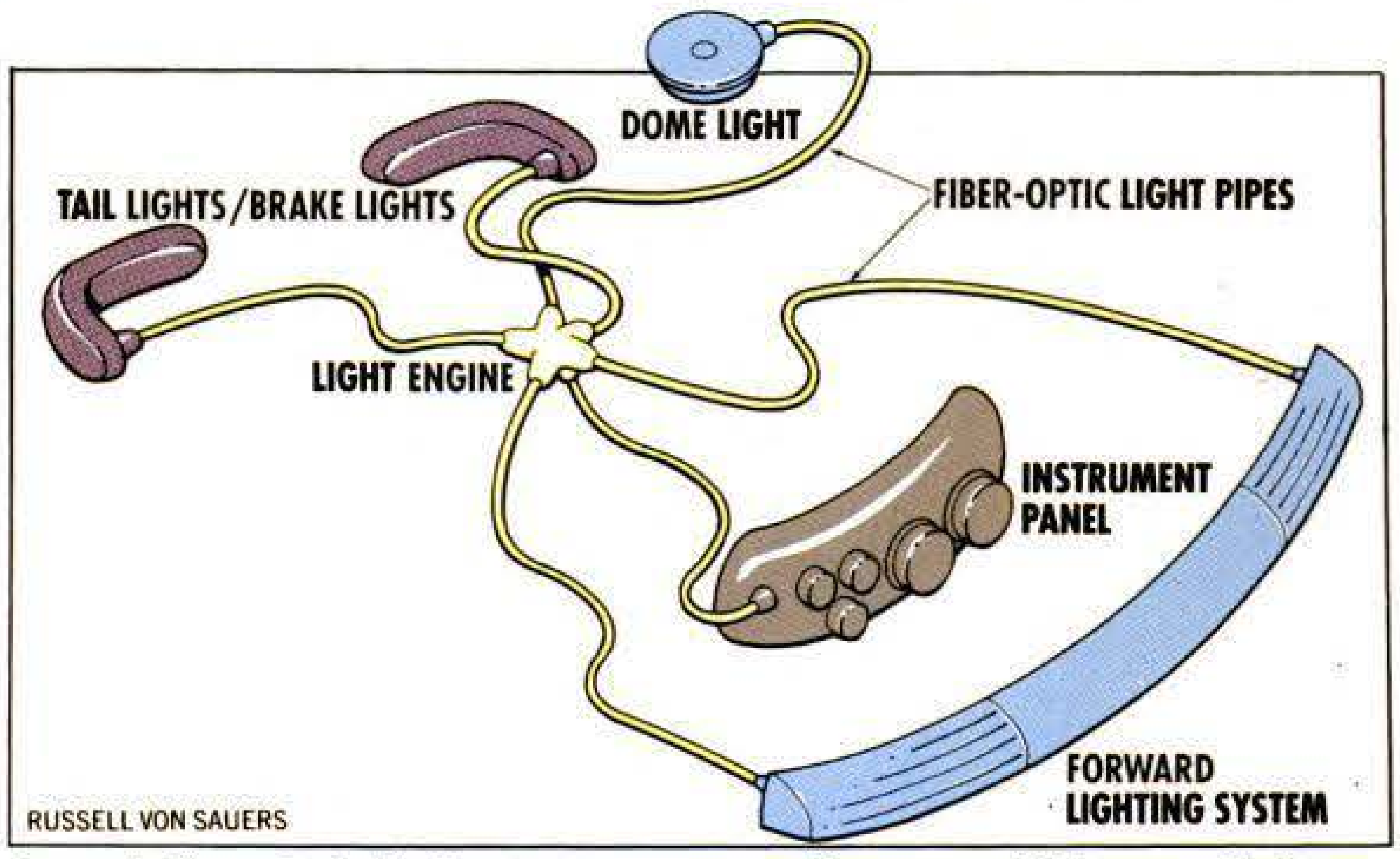
Micro duo

Ford of Europe is thinking small, as demonstrated by the Zig and Zag, a pair of concept micro-cars from its Ghia design studios in Turin, Italy. The diminutive pair, a roadster and a multipurpose utility vehicle, have been built on a shortened (88-inch wheelbase) version of the front-drive Fiesta platform. With an overall length of less than 12 feet, they are just the sort of urban scooters that would make perfect homes for high-efficiency two-stroke engines. In their present form, though, they are powered by European-spec Fiesta engines.

Zig, the sporty two-seater in metallic black (foreground of photo), is seen as a modern interpretation of the classic British roadsters of the 1950s and '60s. It has full-size alloy wheels shod with low-profile, low-rolling resistance tires. They're positioned out at the body corners for minimal overhang, making the car an unusually compact package, which should help in zigging and zagging through congested urban traffic. The steeply raked windshield is integrated into the engine hood, which flips up as a whole unit. Access to the rear luggage compartment is through a roller-type door behind the cockpit.

Zag, in brilliant white, is seen by its designers as the first of a new generation of micro-vans. With removable rear seats and a front passenger seat that slides fully forward, load space has been maximized. A horizontally split tailgate wraps around the rear quarters to ease loading, and a retractable-roof mounting system simplifies transport of large sports equipment outside the cabin.

To ease design and assembly, Zig and Zag are built with common door and lower body panels. Both cars also share a headlight system that replaces halogen units with fiber-optic light cables that convey light to the front of the car. These light pipes terminate at fingernail-size lenses molded into a slot above the front bumper. Ford sees such sub-Fiesta cars as a natural downward extension of its range. Because of their modular construction, an entire family of micro-vehicles (including pickup trucks and sedans) could be built primarily with off-the-shelf components.



RUSSELL VON SAUERS

General Electric's Light Engine incorporates the automobile's many lighting functions into a centralized unit.

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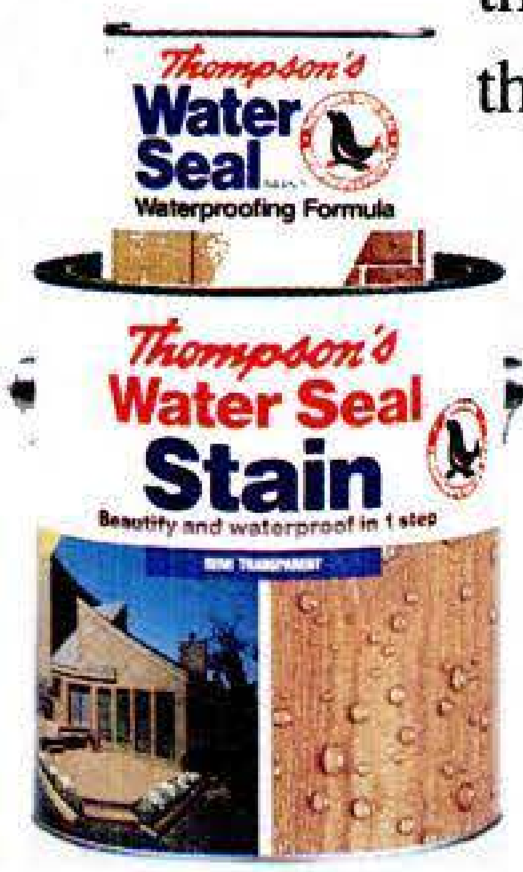

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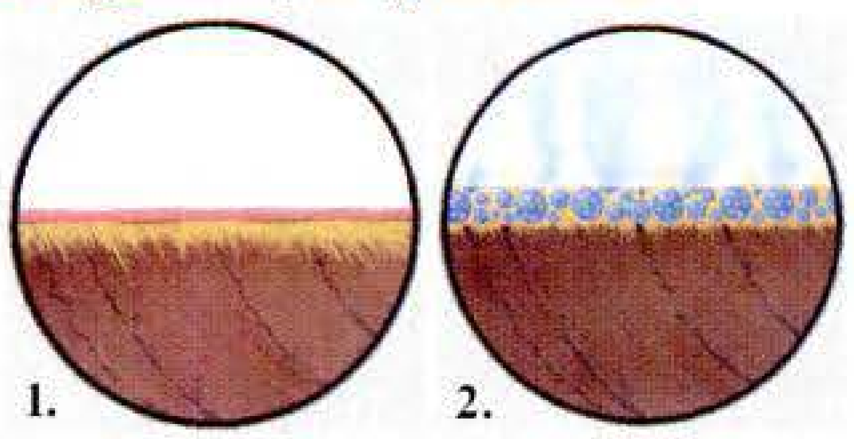

to anchor the color throughout the wood and protect against chipping and flaking. At the same time (Diagram 2) it bonds to the surface fortifying it and protecting against chalking and fading. All the while Thompson's® Water Seal® works to protect against the ravages of water and weather.

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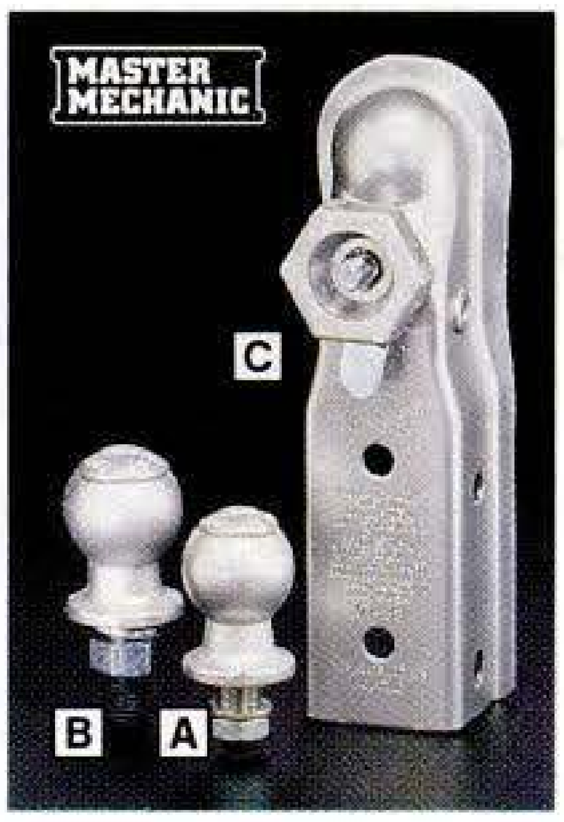

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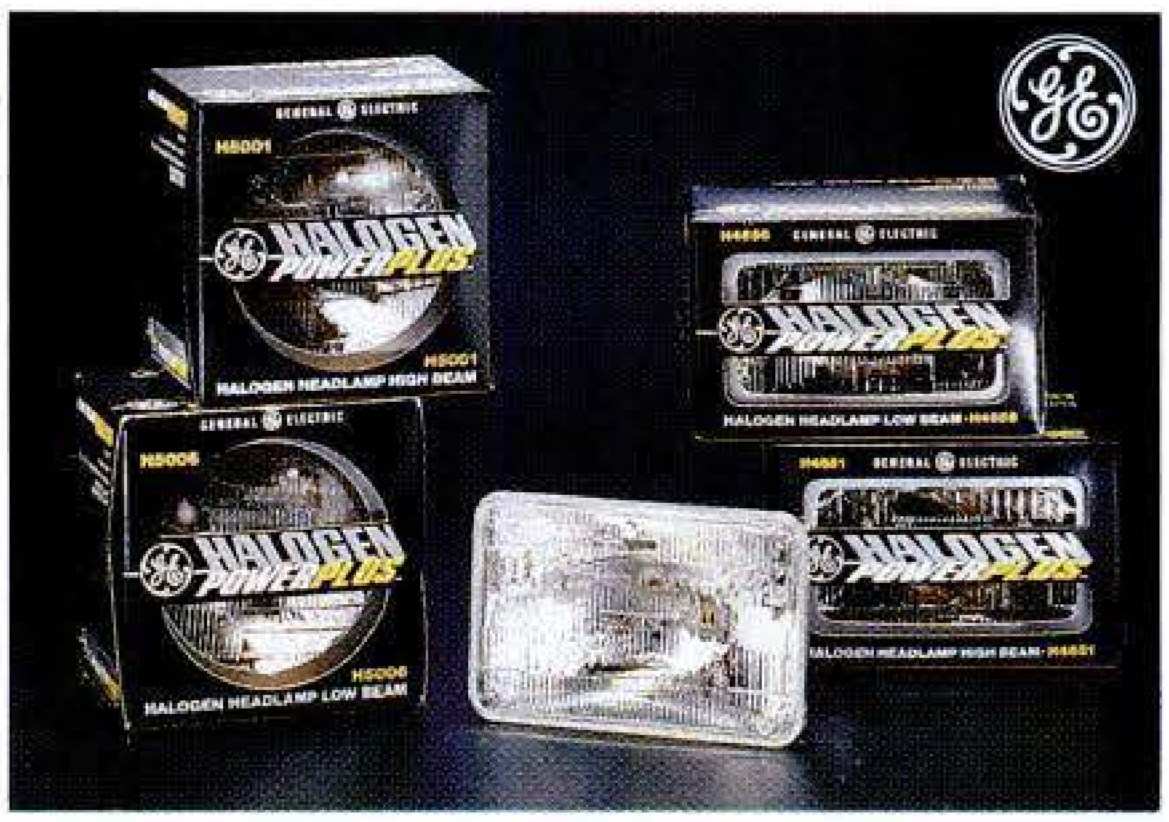

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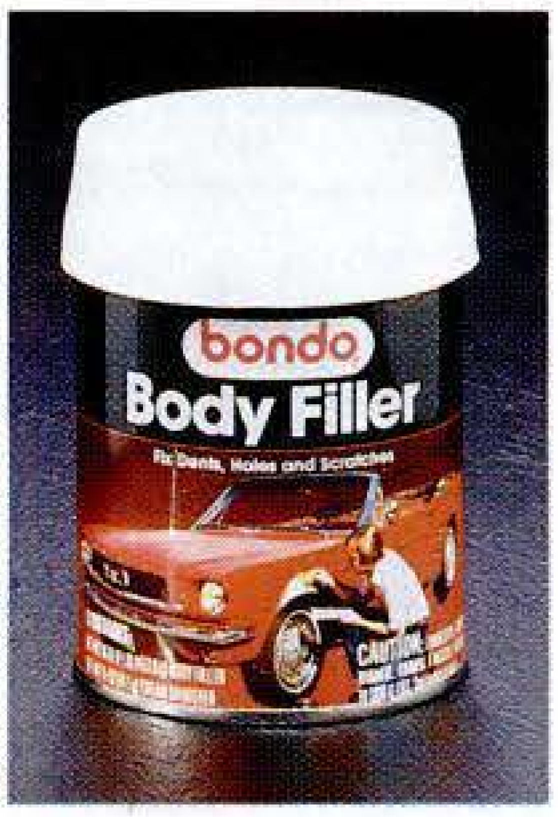

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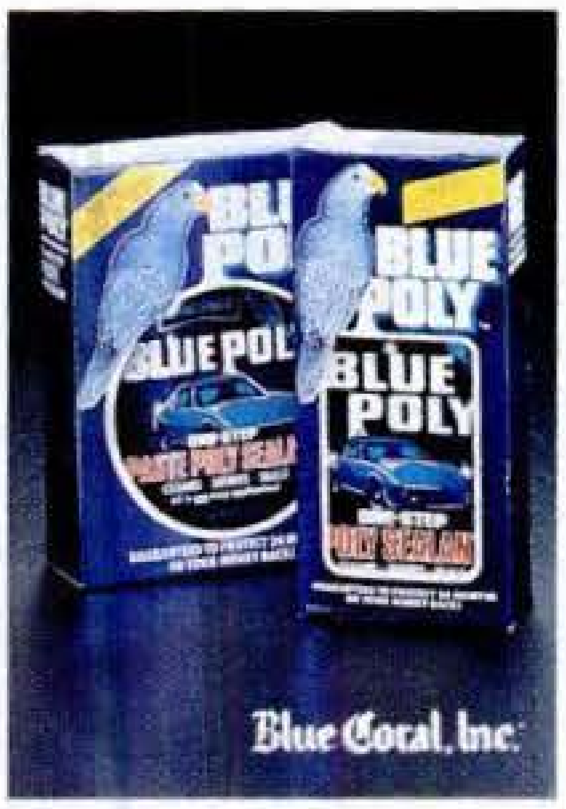

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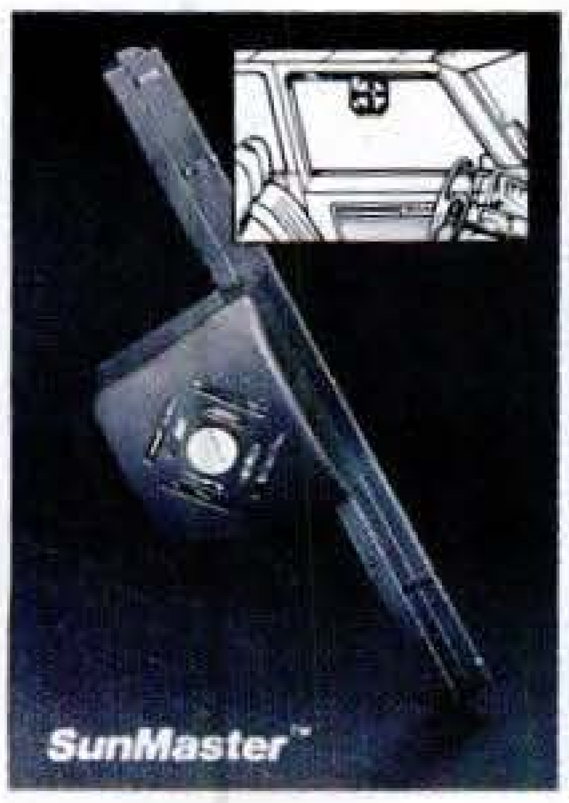

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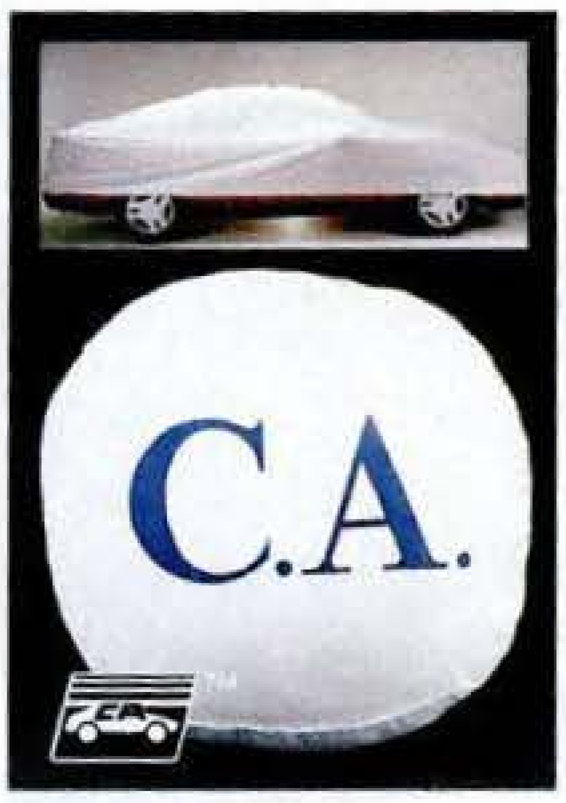

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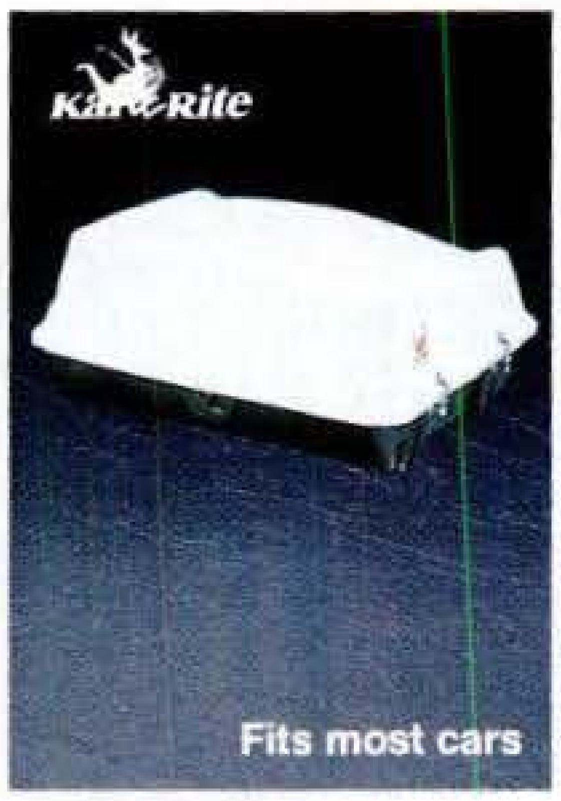

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SPACE-EFFICIENT LUXURY

How much are luxury-car buyers willing to spend for a four-cylinder compact sedan? Nissan's Infiniti division will test those waters with a new car unveiled at the New York auto show. Called the G20, this four-door comes equipped with air conditioning, anti-lock brakes, and a long list of power accessories. An automatic transmission, a power sun roof, leather upholstery, a CD player, and a cellular telephone are the only options available.

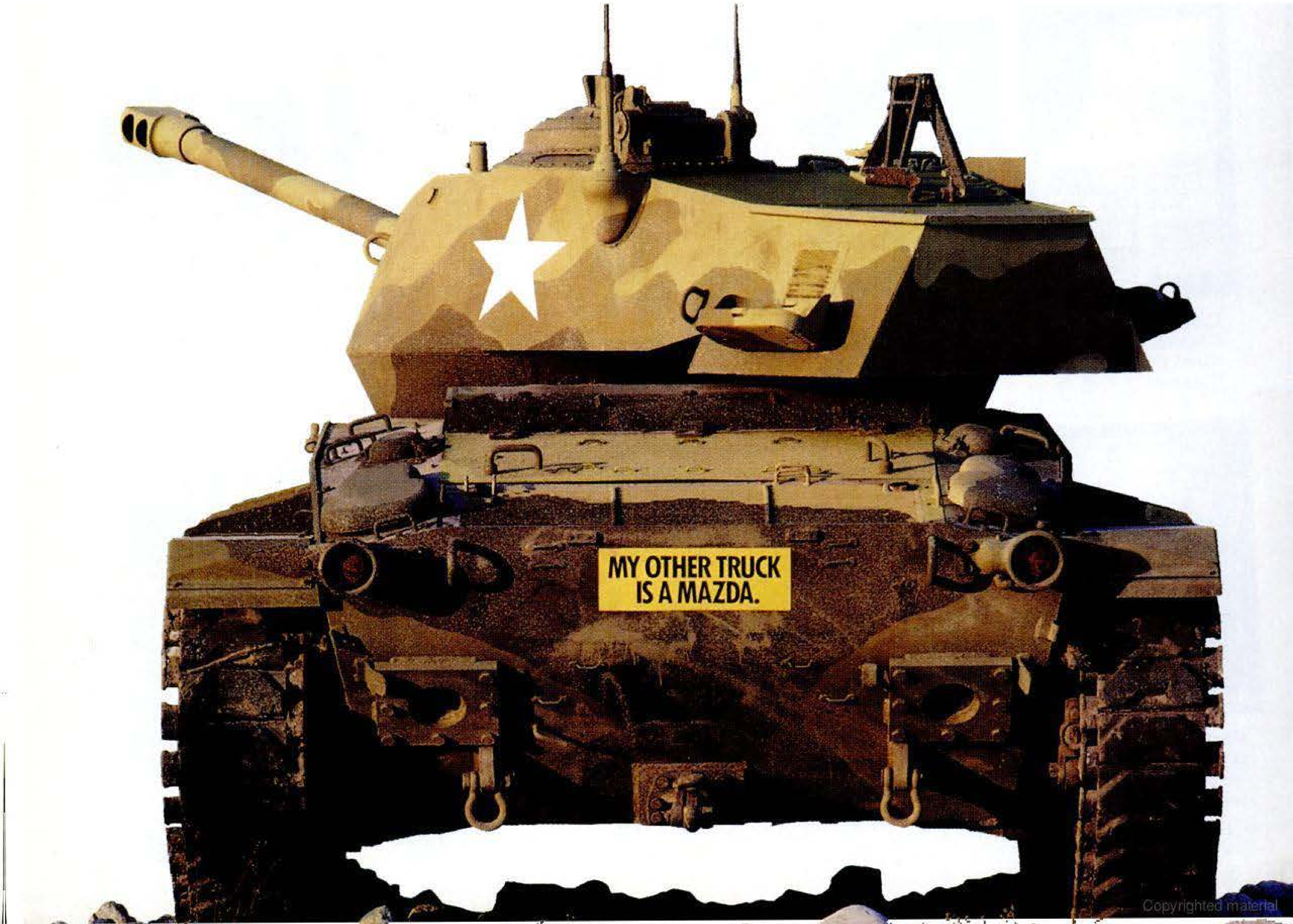
By using what car designers are calling a "cab-forward" body layout, the G20 has the enviable combination of a roomy interior and tight exterior dimensions. Passenger volume is just below that of the 1990 Honda Accord four-door, even though the G20 is 10 inches shorter in length. Its front suspension is the four-link design shared by the Nissan 300ZX and Infiniti Q45 ["Two-seat Heat," Sept. '89]. The rear suspension is a simpler three-link (plus strut) independent design.

While prices have not yet been announced, Infiniti officials say the G20's base price will be under $20,000.—*Don Sherman*

ual task, an interior dome light, for example, can't possibly use the same source of illumination as the headlight system.

Now General Electric Co. has engineered a way to do just that, safely and economically. The Light Engine central lighting system (see diagram on page 32) consolidates all of the car's illumination functions, replacing them with a single compact source. Octopus-like tentacles reach to all corners of the car, delivering the light to where it is needed. Not only does this system consume less power than the assortment of bulbs currently used, it also uses a bulb that GE says lasts six times longer than today's best halogen headlight.

The system is based on a star-shaped arc discharge bulb that supplies light to a series of fiber-optic light pipes that transmit the illumination. The proper routing of the light beam, and possibly even its color, is controlled by a device that acts as an on-off switch, ensuring that the light is delivered to the correct branch of the system. For example, when the brake pedal is pressed, the light valve corresponding to the brake light's fiber-optic cable



would be activated, transmitting energy through the network to the output. Other lighting outputs in the system include turn-signal lights, the cabin's dome light and instrument panel, and the headlights.

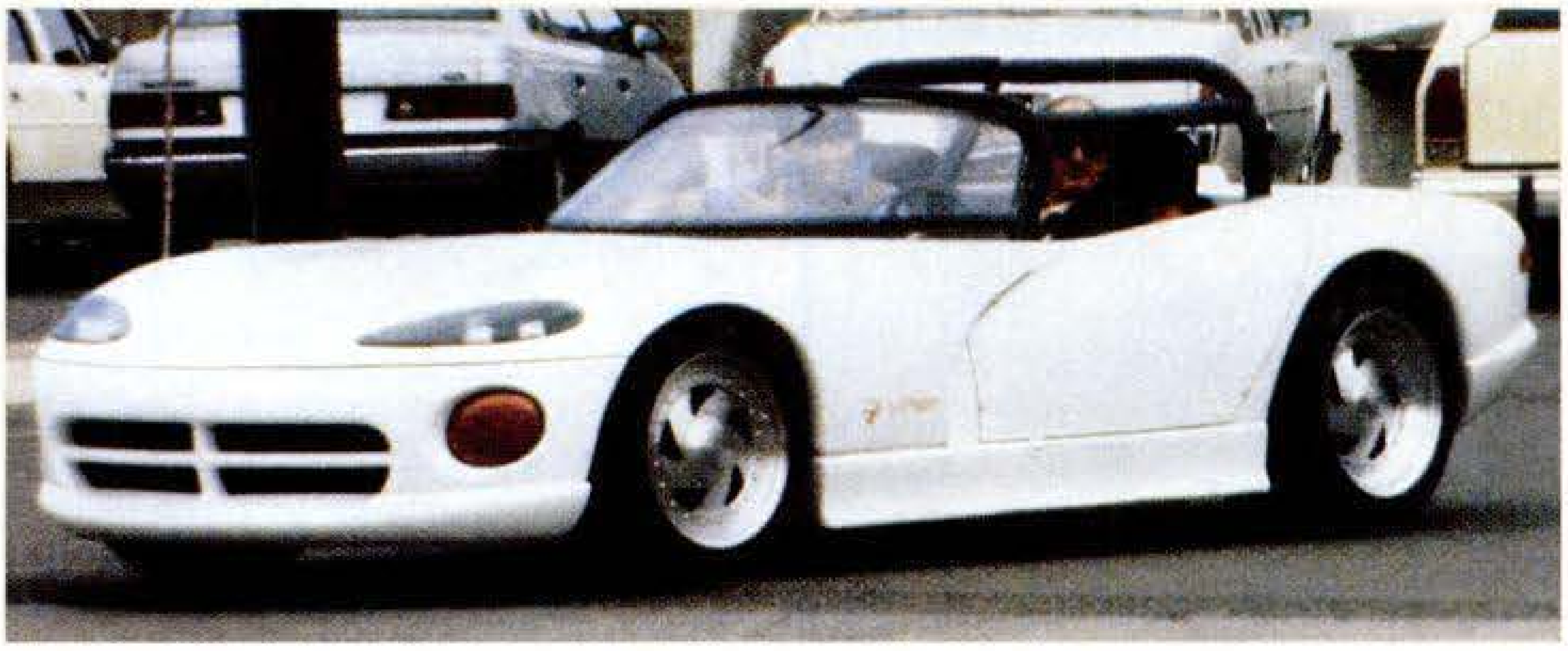
But GE engineers say their centralized light system would have the most startling impact on the headlights. Without the constraints imposed by traditional rectangular headlamps, stylists would be free to consider novel body shapes and contours, and even integrate the headlights, parking lights, and turn signals into a single horizontal bar mounted just above the bumper ["High-intensity Headlights," May].

While the prospects for this centralized lighting scheme are in the future, high-intensity lamps are up and running now in headlight applications. I recently drove a prototype Buick Reatta equipped with GTE high-intensity discharge lamps that replaced the conventional pop-ups with a narrow band of light across the front of the car—two headlamps and two driving lights. The effect on road signs was dramatic as certain colors picked up the high ultraviolet content of the light and glowed far beyond the headlight beams. 3M Corp. reportedly is working on a special highway paint to take advantage of the effect.

The interest in new high-intensity discharge lighting systems for automobiles is partially hobbled by current lighting standards that limit total light output in the interest of preventing the glare from blinding oncoming drivers. But I noticed little protest from oncoming drivers, despite leaving on the high-aimed driving lights. From the front, the narrow reflectors made possible by the new arc lamps seem to produce less glare, even when aimed high.

According to Tom Willis, GE's gen-

VIPER SLITHERS INTO THE OPEN



Chrysler chief engineer and vice president Francois Castaing takes the first Viper prototype for a test drive. In its evolution from show car to prototype road car, the Viper has not only lost its side exhaust pipes, but has traded its V10 for a 5.9-liter Dodge truck V8 and a six-speed manual transmission. Meanwhile, Chrysler chairman Lee Iacocca says there is a 75 percent chance the company will build the sexy two-seater. The first of an estimated 10,000 Vipers could be on the road by early 1992.—*B. N.*

How would it feel attacking dry washes, instead of merely surviving them? To literally plow through mud pits, rather than circle them? It would feel like a new Mazda 4x4 Truck.

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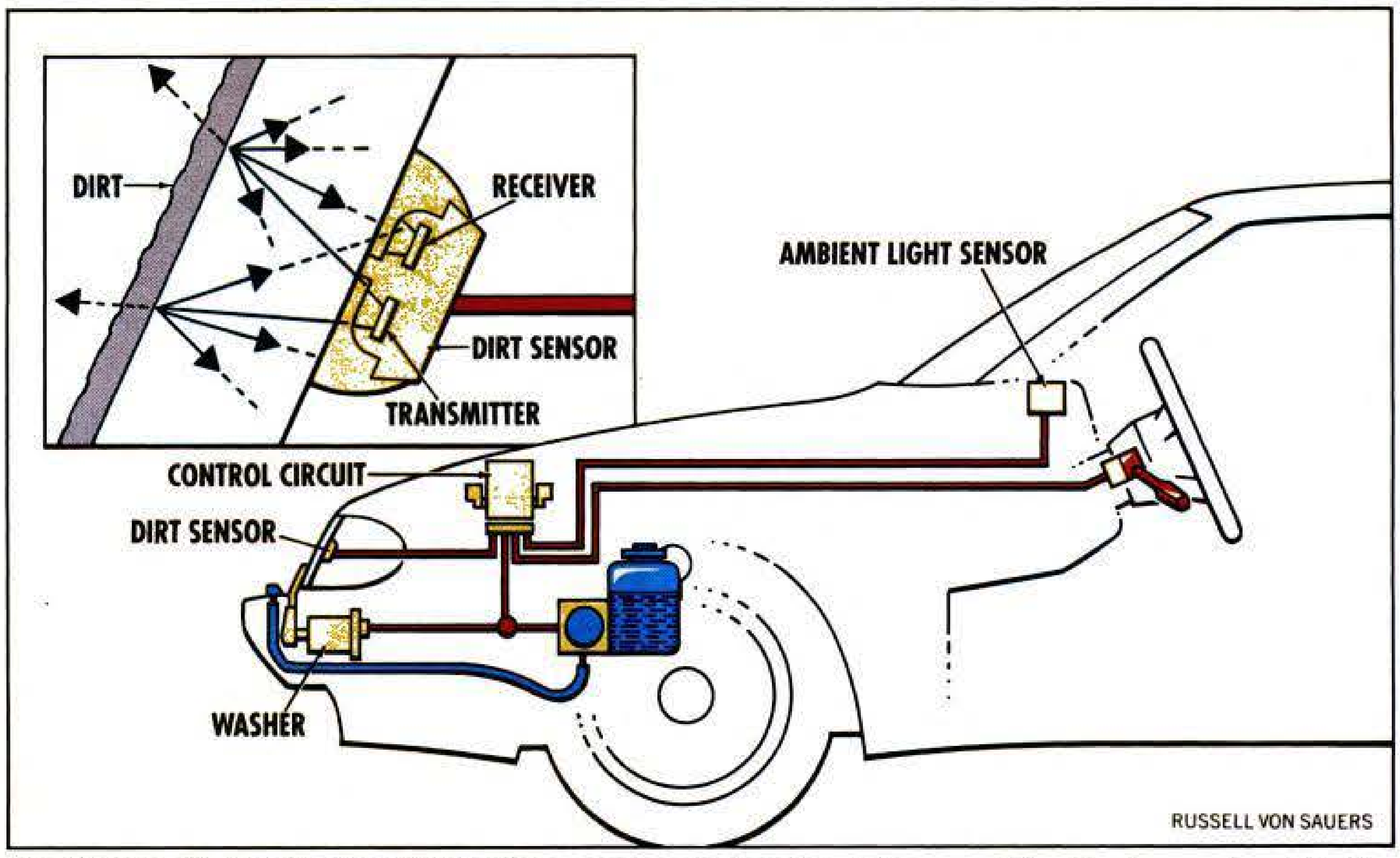


RUSSELL VON SAUERS

The Bosch self-cleaning headlight system senses dirt accumulation, washing the lens automatically.

eral manager for worldwide automotive lighting, the possibilities for centralized lighting layouts are seemingly endless. "This is a built-in system that eliminates the need for many of the systems car manufacturers have been using since day one," says Willis. "It will mean a whole new way of thinking in car designs."

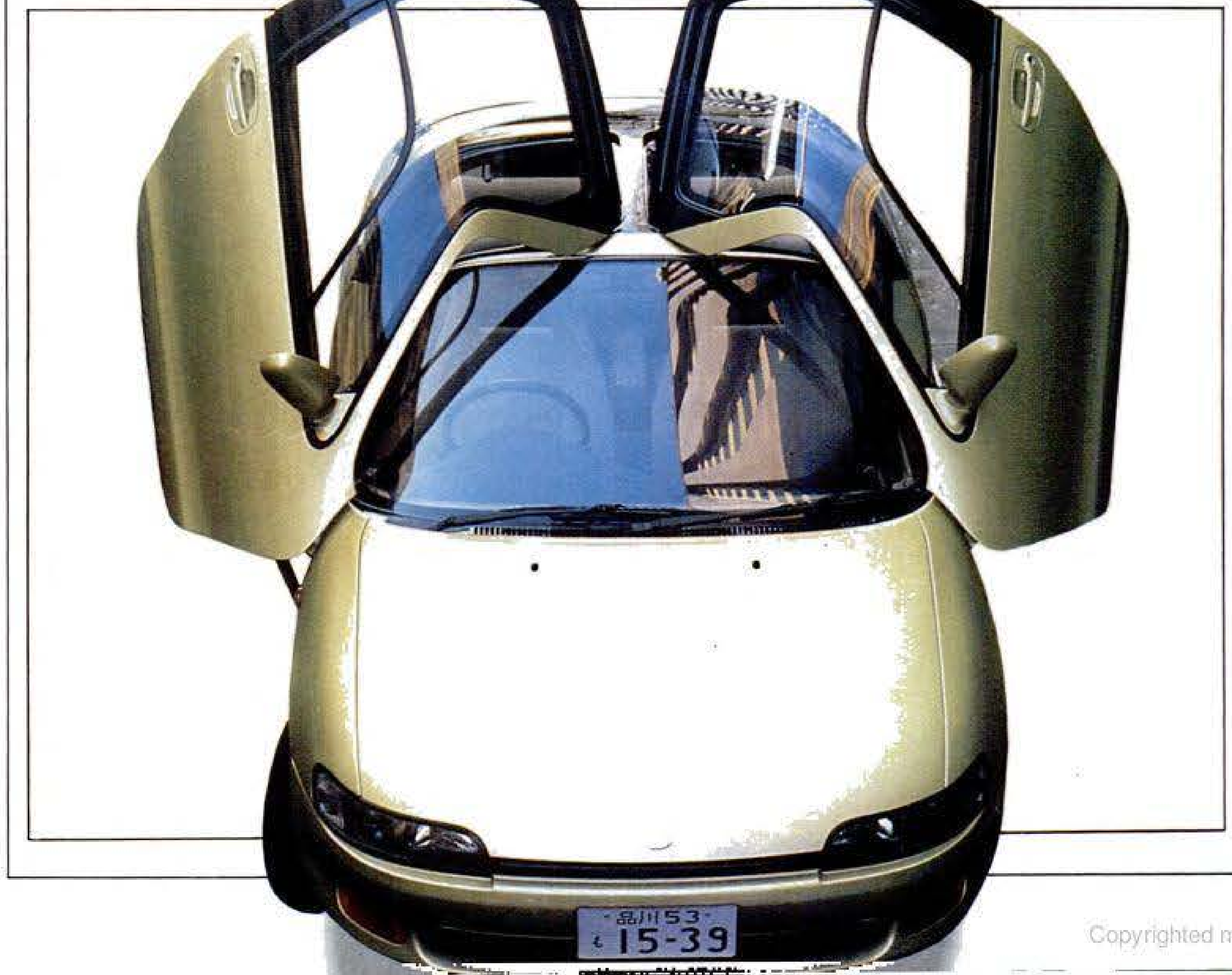
Toyota's new wings

Toyota has just introduced what it says is the first mass-produced Japanese car with gull-wing doors. The Sera sporty compact first appeared as the AXV-II concept car at the 1987 Tokyo auto show, and is aimed at young Japanese city dwellers in search of automotive self-expression.

The Sera's designers had the goal of creating a completely glass cabin, but had to settle for a central T-bar steel roof support with the door's windows sloping off to either side. An all-glass hatchback covers the rear. Rather than a straight-up-and-down gull-wing door as used on the classic Mercedes-Benz 300SL, Toyota engineers opted for a pivoting arrangement. Each door has two hinges: one above the windshield near the roof's center, the other just below the windshield pillar, allowing the door to swing up and out. The greatest benefit appears to be easing access in a parking lot: The fully opened door projects only about 17 inches from the body.

Getting in and out of the Sera is a bit easier than a similar-size car with conventional doors, although you have to be careful not to bang your head on

The gull-wing Sera is Toyota's first attempt at a full-glass greenhouse. The doors pivot to open.



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the horizontal part of the door. It is also a little surprising to have to swing the door up to open it. A single damper/strut, similar to those used on hatchbacks, eases lifting and holds the door open. A second piston inside the door compensates for temperature changes so that the force required to open the door remains constant.

Toyota engineers saw two potential problems en route to bringing this design to showrooms. They considered the likelihood of rain or snow falling on the seat when the doors are open, but believe the seats are no more exposed than a car with conventional doors. The other worry: getting out of the car following a rollover crash. If the car lands on its roof, passengers will have to escape by climbing out the windows, according to Toyota.

The car comes equipped with power steering, power windows, and air conditioning, and is powered by a 1.5-liter four-cylinder engine that generates 110 horsepower. For those inevitable summer days when the sun is unbearable, molded panels snap into the glass roof to shade riders.

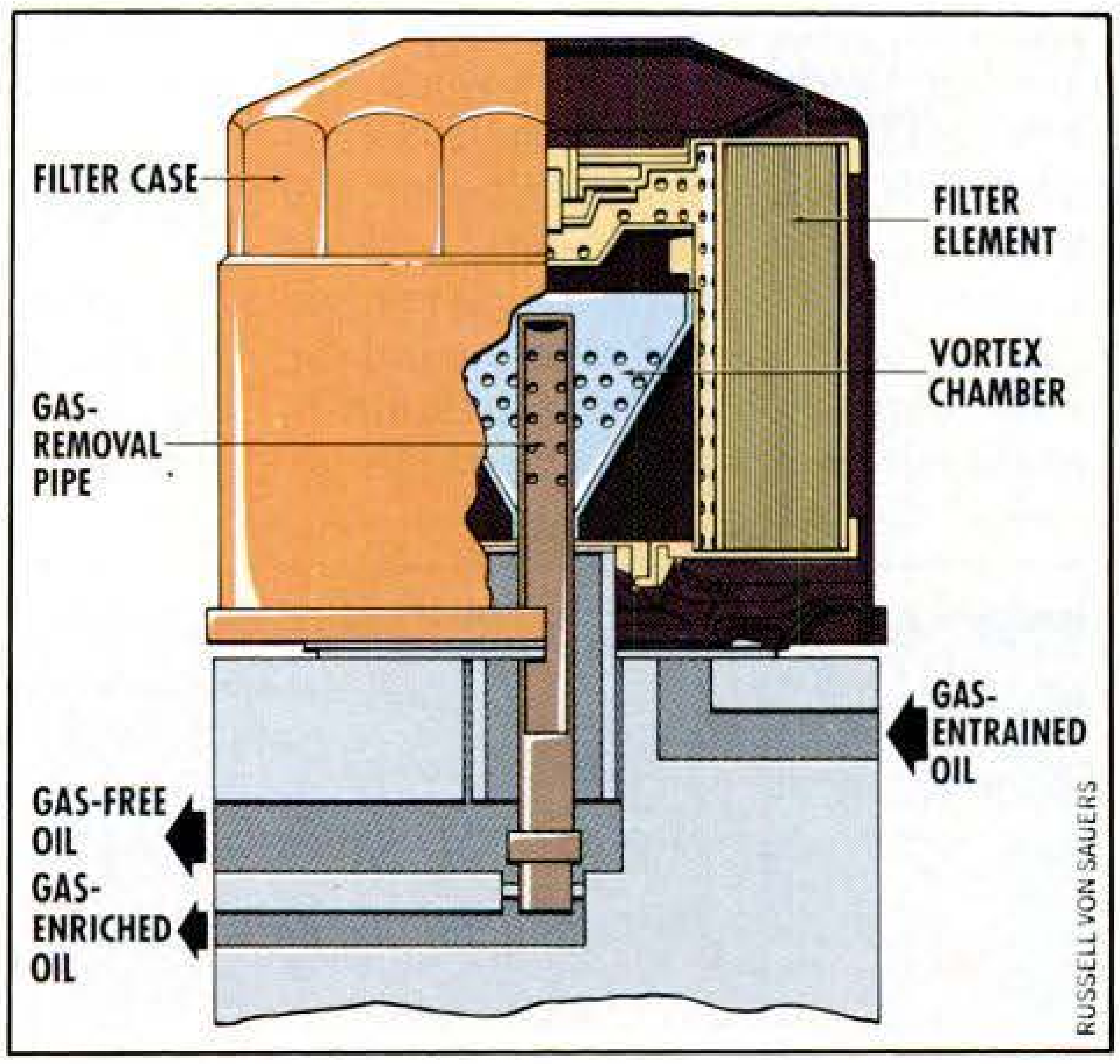
Der Schmutz Sensor

Here's one more innovation that will forward the cause of nighttime driving safety: German automotive components manufacturer Robert Bosch GmbH has come up with an automatic headlight washer that keeps the beams at full illumination.

A study by Bosch shows that most drivers don't notice the gradual dimming of the headlights as dirt builds up on the headlight lens until road illumination drops to half-strength. To overcome this human failing, Bosch bonds a tiny dirt detector— sonorously called a "schmutz sensor" by Bosch engineers—to the inside of one headlight lens.

The device transmits infrared radiation that is scattered and reflected by dirt on the lens back to an optical sensor. When the electronic control unit determines that too much goop has accumulated on the headlight, the washer/wiper is activated for a timed period, or the driver can switch to a warning-signal light for manual operation. The system is designed to avoid excessive water consumption by fixing a minimum interval between washes. An ambient light sensor turns it off during the day. For nighttime driving, the auto-washer is not tricked into operation by street lamps or approaching headlights because the dirt sensor responds only to its own infrared beam.

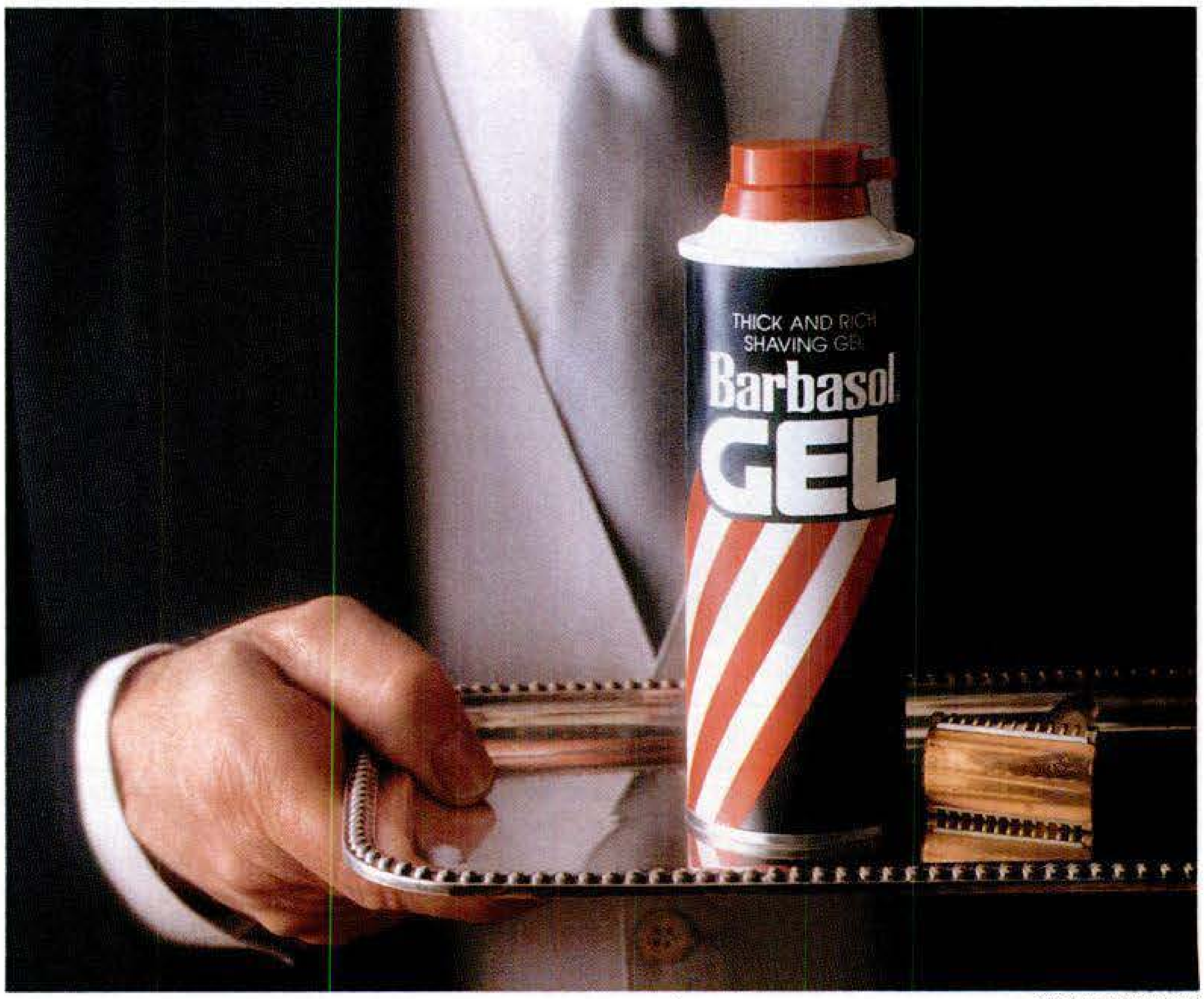
DUAL-ACTING OIL FILTER



RUSSELL VON SAUERS

To get the most from engine oil, it must remain pure lubricant, free of contaminants. Now Mitsubishi Oil Co. (the Delaware-based subsidiary of the Japanese industrial conglomerate) has developed a new filter design that removes air and gas bubbles from oil as well as solid particles, improving the efficiency of the lubrication system. The Vortoron filter separates solid contaminants from the oil stream with conventional filter paper on the outer radius of the filter case.

From there the clean but still aerated oil is routed through what Mitsubishi designers call a vortex flow chamber, where the bubbles are taken out of the stream by centrifugal force. The filtered and degassed lubricant goes to the engine, while the remaining bubble-enriched oil is returned to the oil pan and eventually recirculated into the lubricant flow. Mitsubishi says the vortex chamber removes up to 80 percent of the gas bubbles formed by the agitation inside the engine, with the only penalty being a slight pressure drop. At present, Mitsubishi is targeting this novel device for use in hydraulic systems, power turbines, and chemical processes that are especially sensitive to bubbles. A dual-acting automotive oil filter is on the way as well.



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Rich.
But not expensive.

Fenders from a waterbed

The high-speed sheet-metal presses that churn out hundreds of millions of parts every year are the heart of modern mass production. They work like giant cookie cutters, and the basic design of the machines hasn't changed significantly for a hundred years. Now Toyota is experimenting with a method of metal forming that uses a solid die for the upper surface, while liquid in a confined vessel acts as the lower die. It's a method that has been used in experimental runs for small parts; Toyota claims it is the first to use it for large-scale auto parts. The trimming of excess material is done by a carbon dioxide laser, further speeding the process.

Impact's go-ahead

To drive home the point that General Motors is serious about producing an electric car, chairman Roger Smith arrived at Washington's National Press Club behind the wheel of a prototype Impact ["ANF," April] electric sports car. Once inside he gave engineers working on the project the go-ahead for production. Smith emphasized that many questions remain as to engineering details, price, and release date, but the world's largest auto maker already appears interested in taking a leading role in electric-car technology.

Skeptics were surprised by GM's acceptance of relatively commonplace lead-acid battery technology, which seems to offer acceptable range and power although the service life of the batteries (roughly 1.5 years) makes battery replacement the biggest operating cost. However, there is ample production capacity in place to manufacture lead-acid cells, unlike experimental and more-exotic alternatives. In fact, GM plans to use non-gassing recombinant batteries that are relatively compact and use a matte electrolyte that prevents leakage if the case is punctured. A 50-percent recharge is expected in one hour.

Even before Smith's announcement had time to sink in, GM's Japanese affiliate, Isuzu, announced a battery advance that has both a high power density and a quick recharge—just the characteristics GM had been waiting for to make an electric car practical.

Smith's speech and approval for the project opens up many questions regarding Impact. Among the pressing

SKY-TOP

C&C Inc. of Brighton, Mich., is reviving the principle of the fully retractable hardtop roof. Its Tresaire concept car goes about the job somewhat differently, though—the roof is completely glass, reinforced with a carbon fiber frame to reduce the weight of the assembly.

The top, which C&C calls Skylite, retracts in steps. For ventilation, one end of the roof can be tilted up slightly, similar to a sun roof. The next stage (center photo) transforms the car into a targa top design, with the roof section acting as a kind of transparent spoiler, hugging the contour of the rear window. Finally, the roof and rear window assembly can be fully retracted, flush with the rear deck, yielding the equivalent of a conventional convertible.

One innovative feature of the car is a "vortex stabilizer" designed to minimize wind buffeting when the top is retracted. Air ducted from the cowl area is routed under the windshield and directed up the passenger compartment side of the glass to reduce the negative pressure area created when the car is moving. Calling the Skylite into action is not something restricted to the driveway; even at 65 mph, the convertible hardtop can be retracted at the push of a button, according to C&C.

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issues left unresolved are how the electric vehicle would be treated under corporate average fuel economy (CAFE) regulations: as a user of no fuel, or the gasoline equivalent of its electrical usage. And, more to the point, whether any CAFE credits gained by Impact would be transferable to the GM line to offset larger gas guzzlers. Smith reported that much progress has already been made in engineering the production Impact, leading to a dozen patent applications so far.

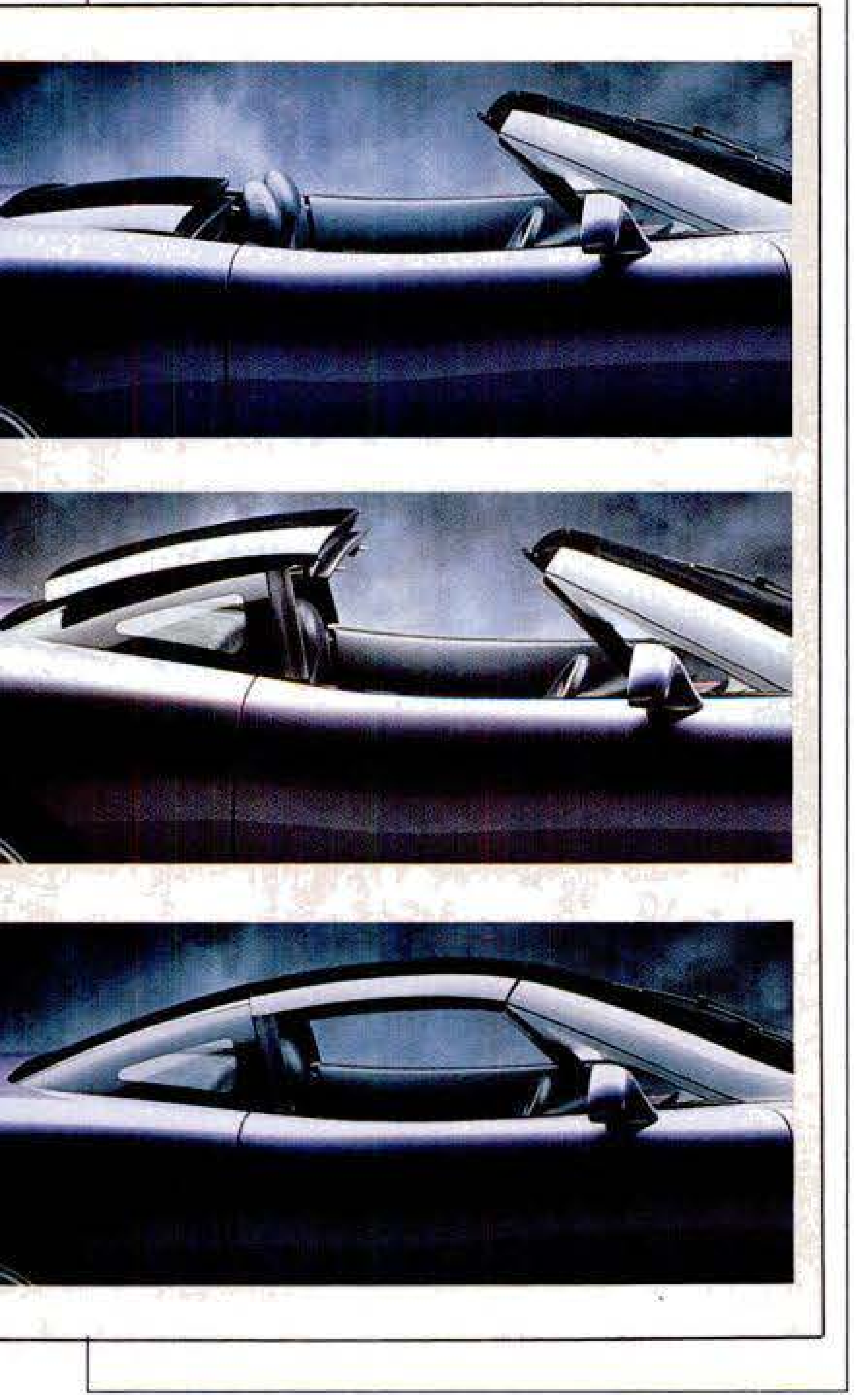
The production version of the Impact is likely to be relatively expensive to own and operate, hence of limited interest unless made mandatory in certain areas. Still, given the pressure to improve air quality in some high-smog cities, an electric car could become as popular as a two-place sports car —enough demand to make the project profitable.

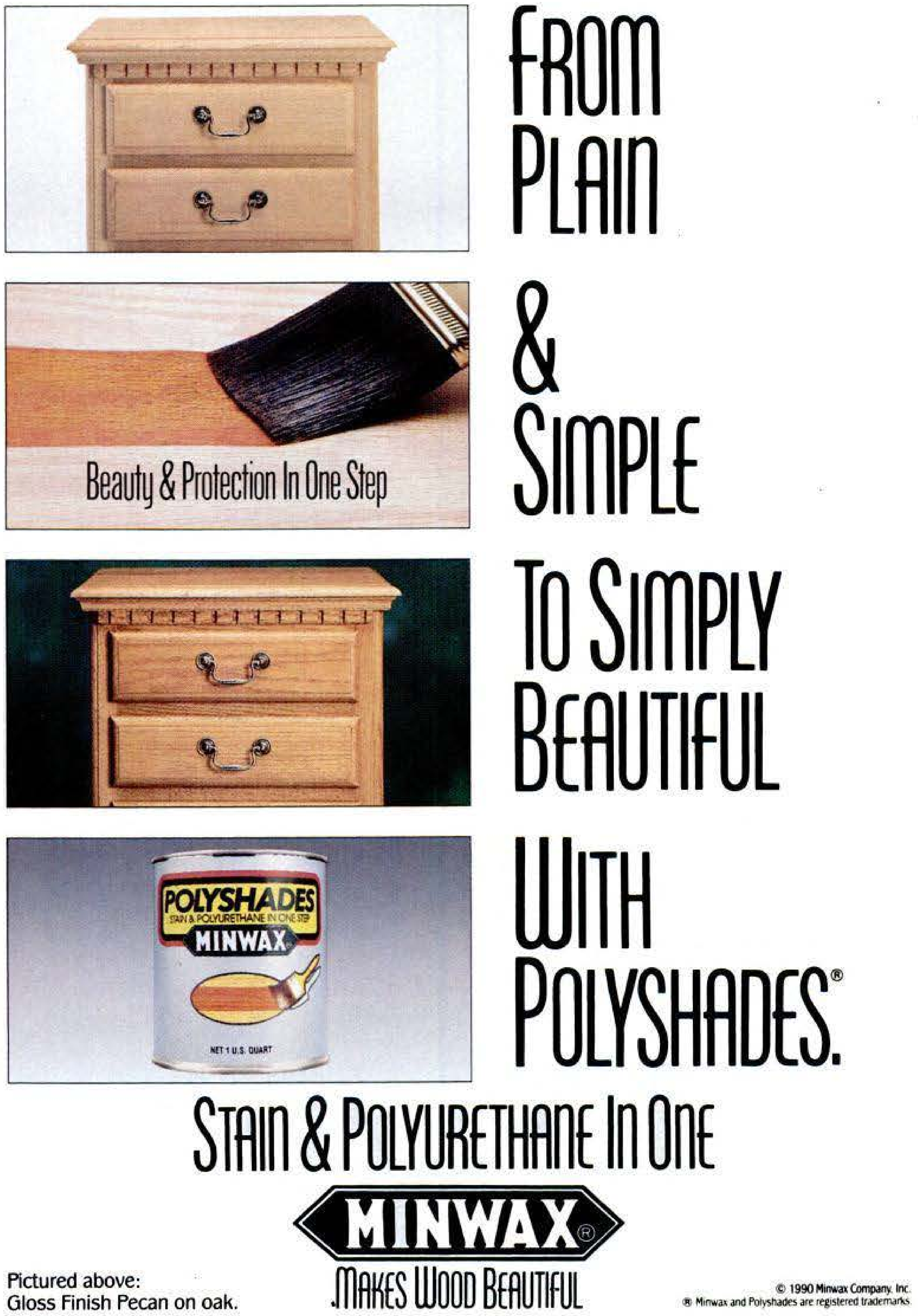
Kinder, gentler Volvo

Volvo's display of the Environmental Concept Car at the Geneva auto show demonstrates that the major manufacturers are starting to take notice of Europe's Green movement. While the Volvo 740 GL looks like any other, under close inspection it turns out to be a showcase of environmentally friendly automotive technology:

- To reduce carbon monoxide and hydrocarbon emissions by 50 percent, the kinder, gentler flexible-fuel Volvo 740 GL runs on M-85, a mix of 85 percent methanol and 15 percent gasoline ["Clean-air Fuels," Jan.]
- With an electrically heated catalytic converter, the cleanup of tailpipe emissions begins more quickly. This is important during the engine's warm-up period: Volvo estimates that during a normal 20-minute drive, 80 to 90 percent of the emissions are released in the first two minutes.
- Solvent-free undercoating and water-based paints reduce volatile organic vapor emissions.
- A prototype air conditioner uses HFC-134a, not ozone-depleting CFC-12, as its working fluid (see cover story); polyurethane-foam interior parts were also made without CFCs.

But the biggest change evident in the Volvo Environmental Concept Car is the change in attitude of an auto maker—now aware that not only safety sells: Being friendly to the planet doesn't hurt either. PS

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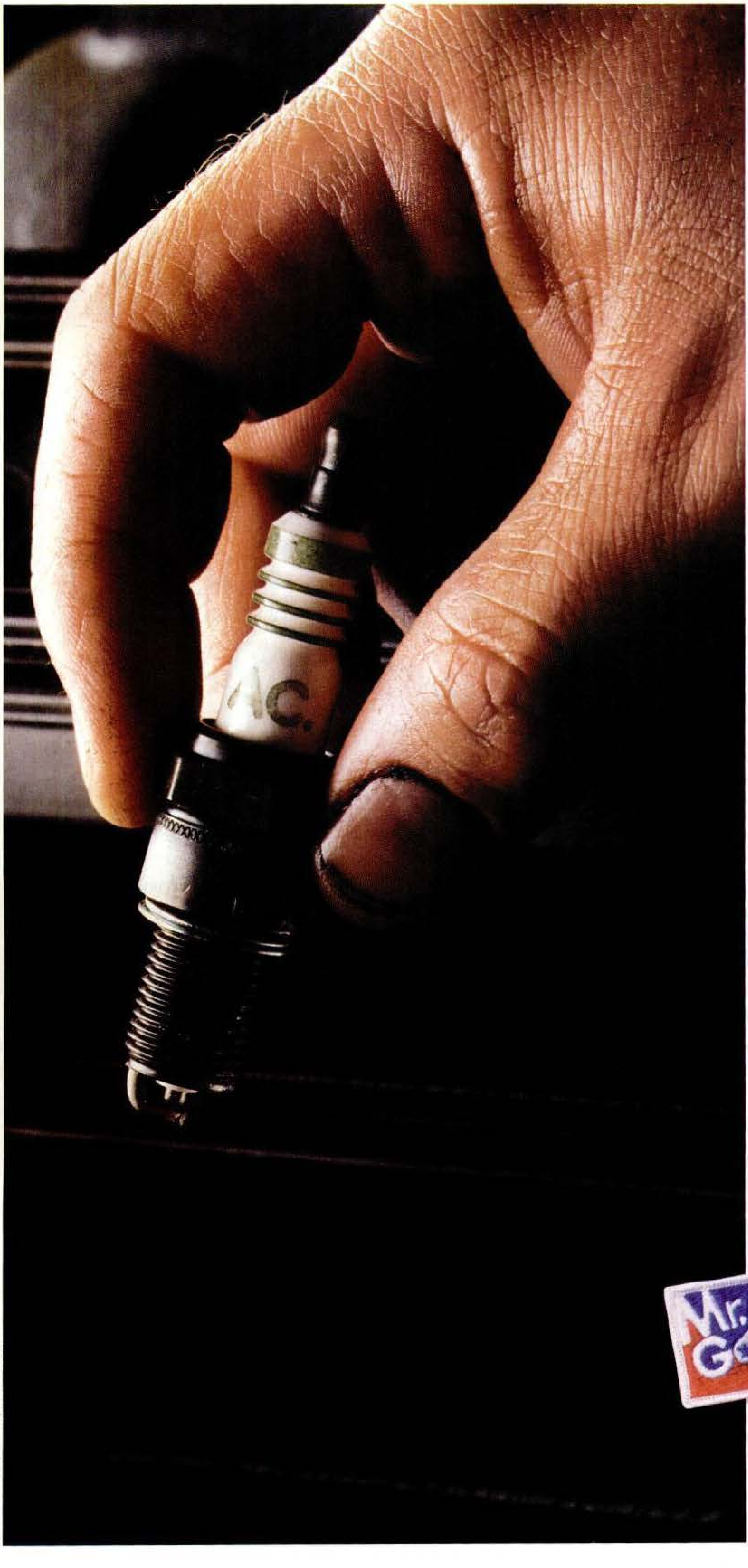

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Electronics Newsfront

By **DAWN STOVER** *with William J. Hawkins, Greg Pearson, and David Scott*

Work-station wars

Mention a work station, and most office workers conjure up images of a tidy cubicle. But to an engineer or scientist, a work station is a type of computer—small enough to be used by an individual, but powerful enough for tasks such as animation and three-dimensional design.

Until recently, personal computers generally couldn't compete with work stations for scientific uses. But as PCs become more powerful and work stations less expensive, the two categories are converging.

Apple Computer recently unveiled its fastest Macintosh ever, a "personal computer" with the graphics capabilities of a work station (see photo). At $8,969 (not including a monitor), the Mac IIfx also rivals work stations in cost.

On the same day, LSI Logic Corp. introduced a microchip set called the SparKit. The $1,327 kit enables manufacturers to clone work stations made by Sun Microsystems of Mountain View, Calif., one of the biggest makers of these machines. Work stations have already shrunk in size to fit on desktops. With SparKit, their prices will shrink as well.

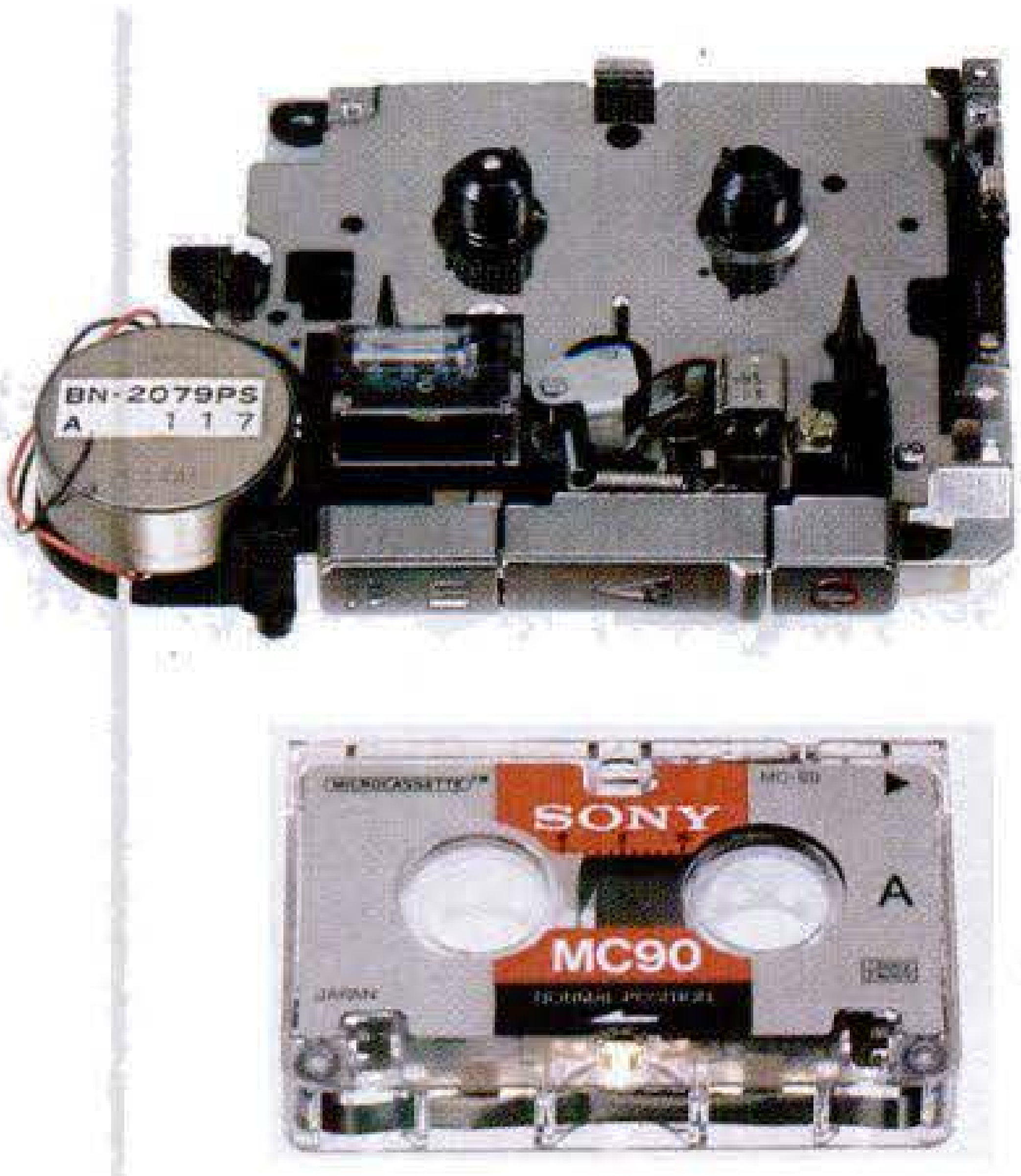
Work stations use an operating system called Unix, while IBM PCs and their clones use DOS or OS/2. Now that companies such as Lotus Development Corp. have begun shipping Unix versions of popular programs, the least expensive work stations are beginning to invade the office market.

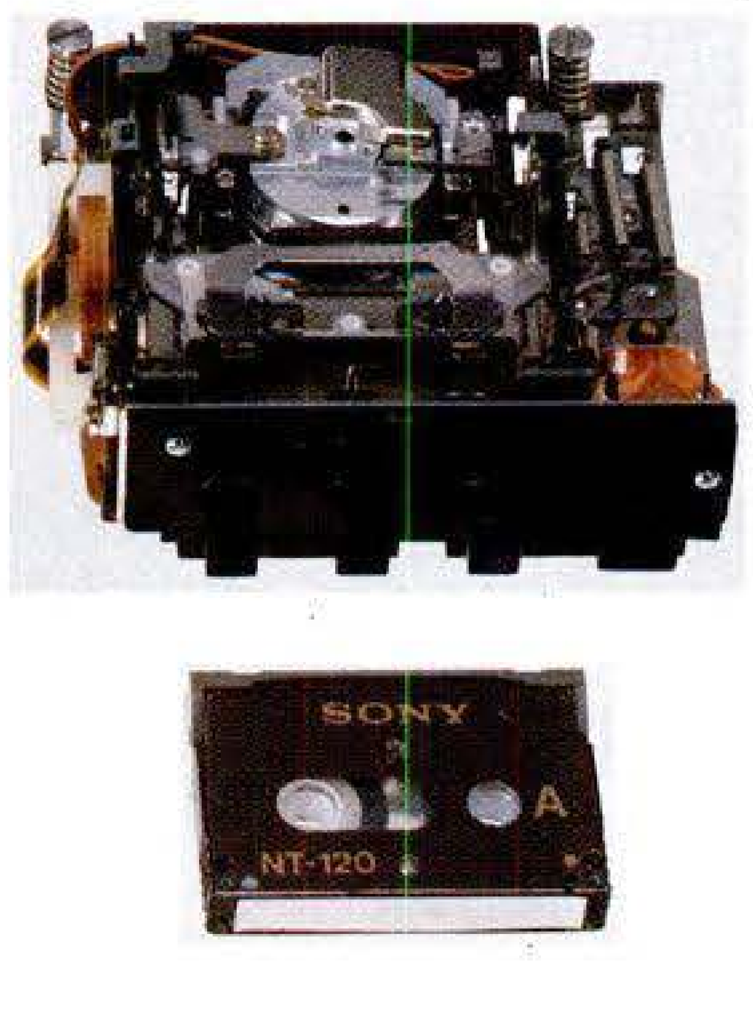
Work station in disguise? The speedy Mac IIfx is powered by Motorola's 40-megahertz microprocessor.

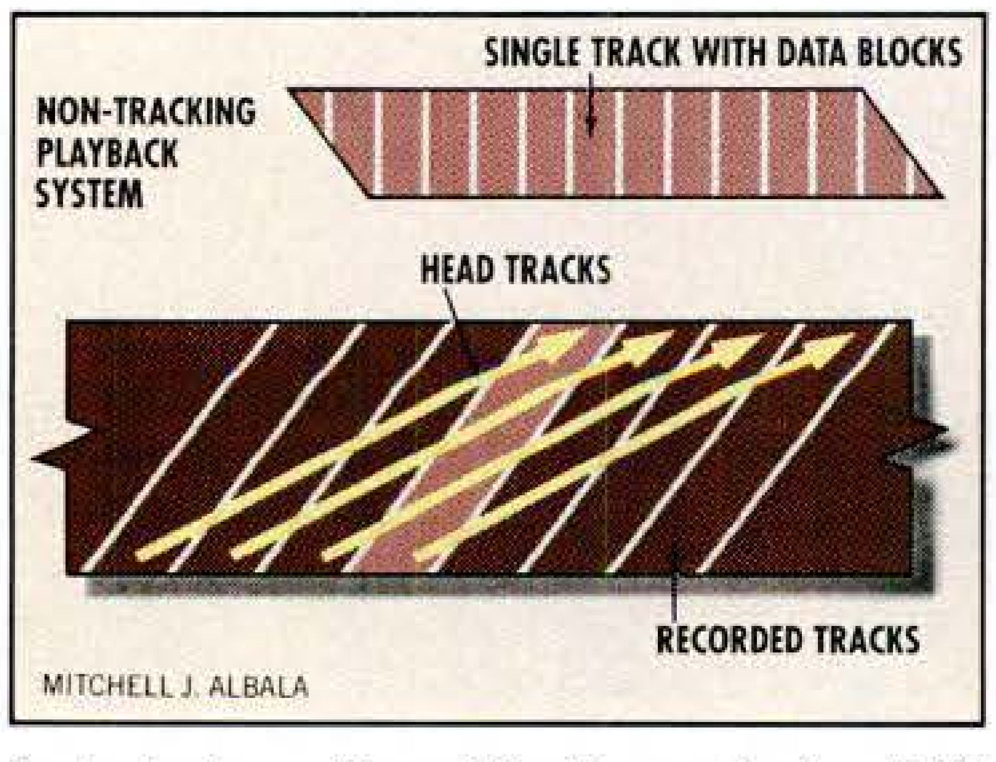
At the same time, higher-priced work stations are taking on the world's largest computers. A few months ago, a researcher at Lawrence Livermore National Laboratories reported that the RISC/System 6000, the $42,705 machine made by IBM, solved some scientific problems faster than an X/MP—one of the fastest supercomputers—made by Cray Research.

Two hours on a postage stamp

It's not much bigger than a postage stamp—and a mere 0.2 inch thick—yet a cassette developed by Sony holds an incredible two hours of high-quality digital audio. The tiny size is made possible by a non-tracking technology incorporated in a memo recorder that Sony recently demon-

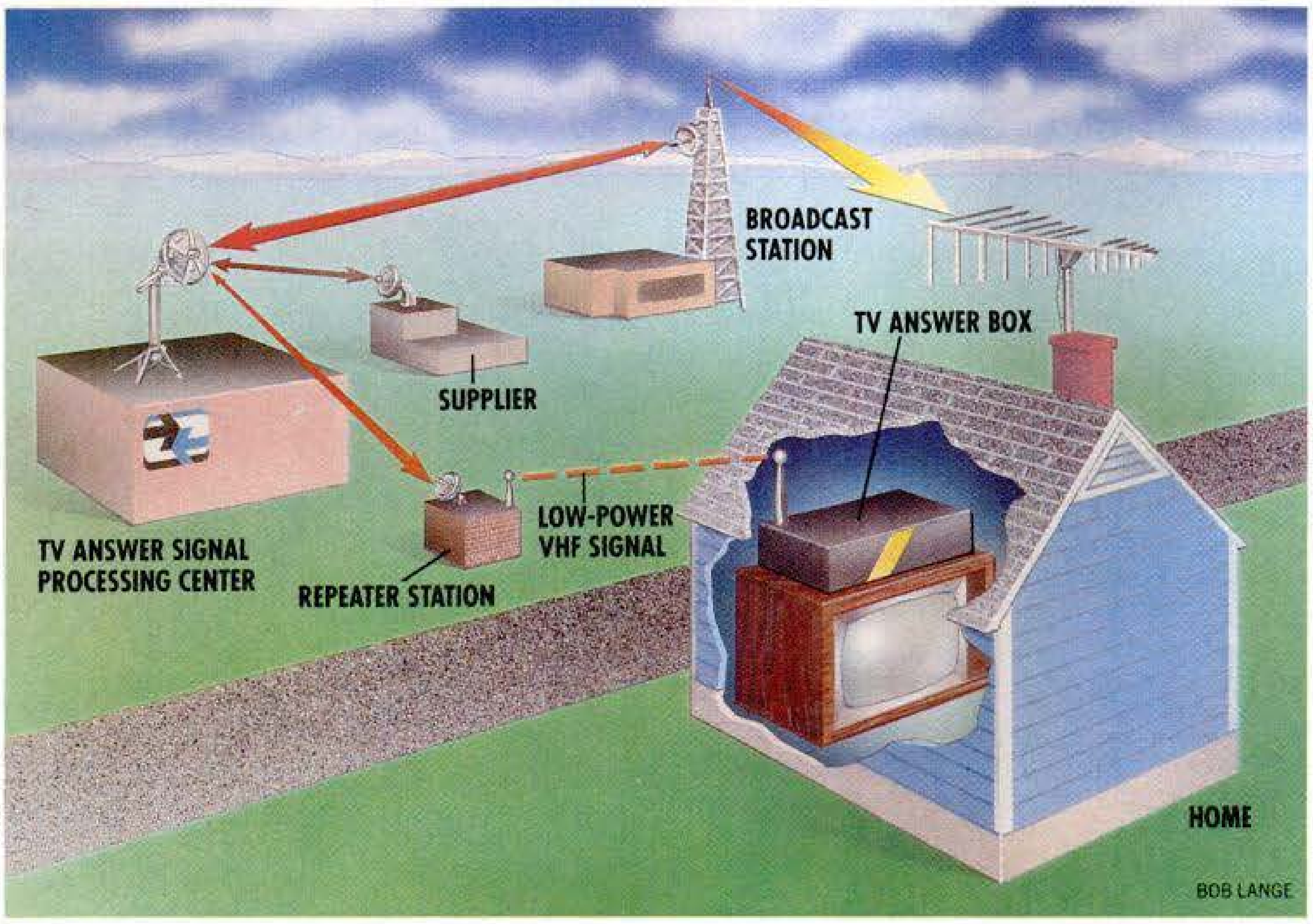






MITCHELL J. ALBALA

A standard cassette and loading mechanism (left) dwarf Sony's non-loading system (right). During playback, blocks of data on a tape (above) are memorized, then reassembled in the correct order and played.



A TV Answer box atop a television sends a viewer's response to a local repeater site, which passes it back to the signal processing center. From there, it's routed to the appropriate supplier.

strated in Japan (see the drawing).

Like a conventional digital audio tape (DAT) recorder, the memo recorder uses a spinning head to record audio as digital data in tracks across the tape's surface. But the memo recorder has an unconventional playback method.

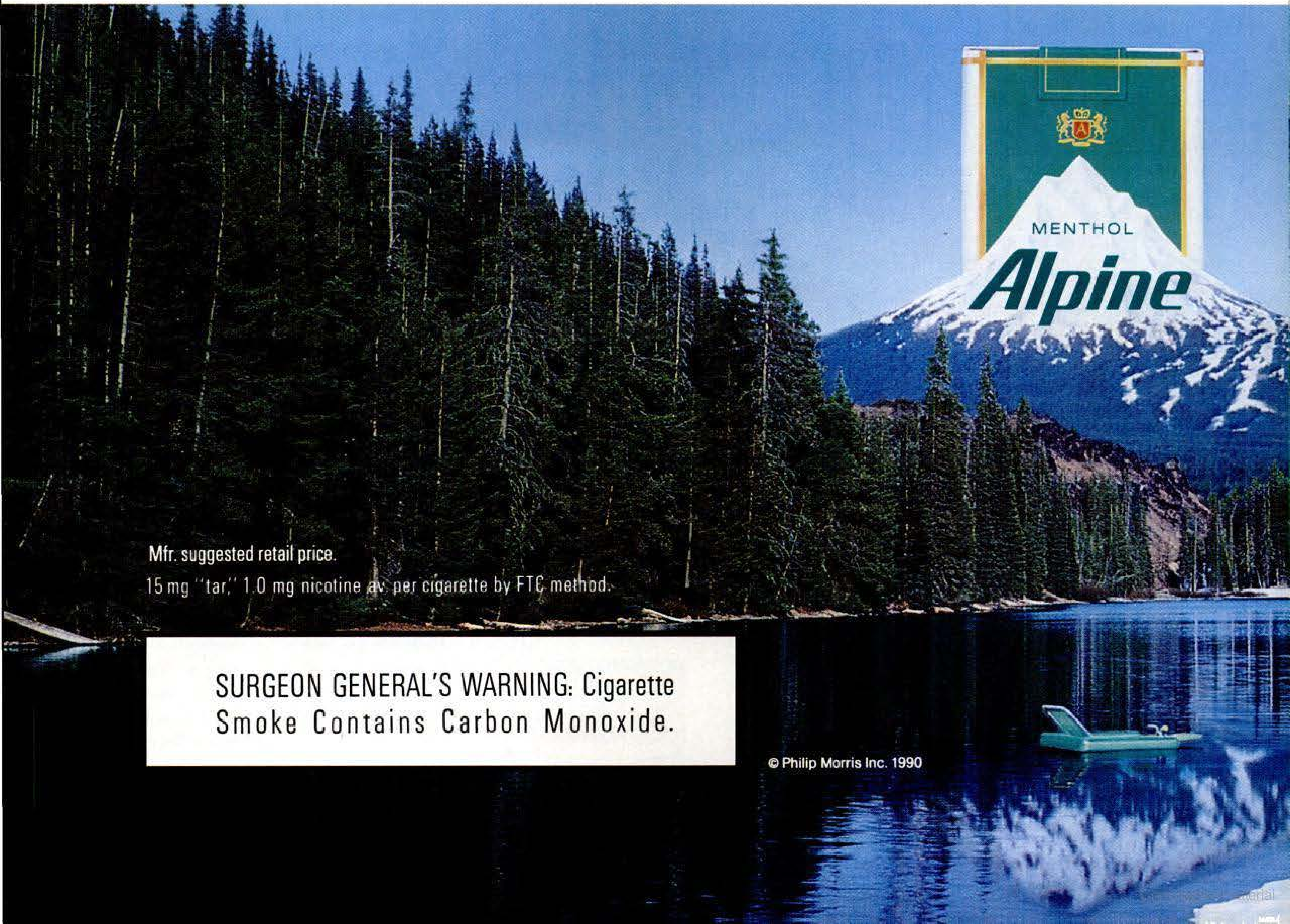
The head on a conventional DAT machine traces each track exactly as it was recorded. That requires an accurate—and bulky—tape-loading system. The non-tracking system isn't that fussy. During playback the head spins twice as fast as its recording speed, identifying pieces of tracks as they go by. Each piece—a block of data—is saved in memory. After an entire track has been identified, the coded blocks are reassembled in the correct order, converted to audio, and played.

At present, the memo recorder's 10,000- to 15,000-hertz frequency range limits its use to voice recording (conventional DAT machines are 10,000 to 22,000 hertz), and it's not for sale. But with a higher bandwidth and larger memory, the non-tracking technology could be applied to future DAT machines and even digital VCRs.

Instant gratification

Imagine being able to order a pizza, go shopping, or take courses from a faraway university without leaving your sofa. That's the goal of interactive television ["Do-It-Yourself TV," Nov. '88].

Most interactive systems require a customer to make a phone call—or take other inconvenient steps—to place



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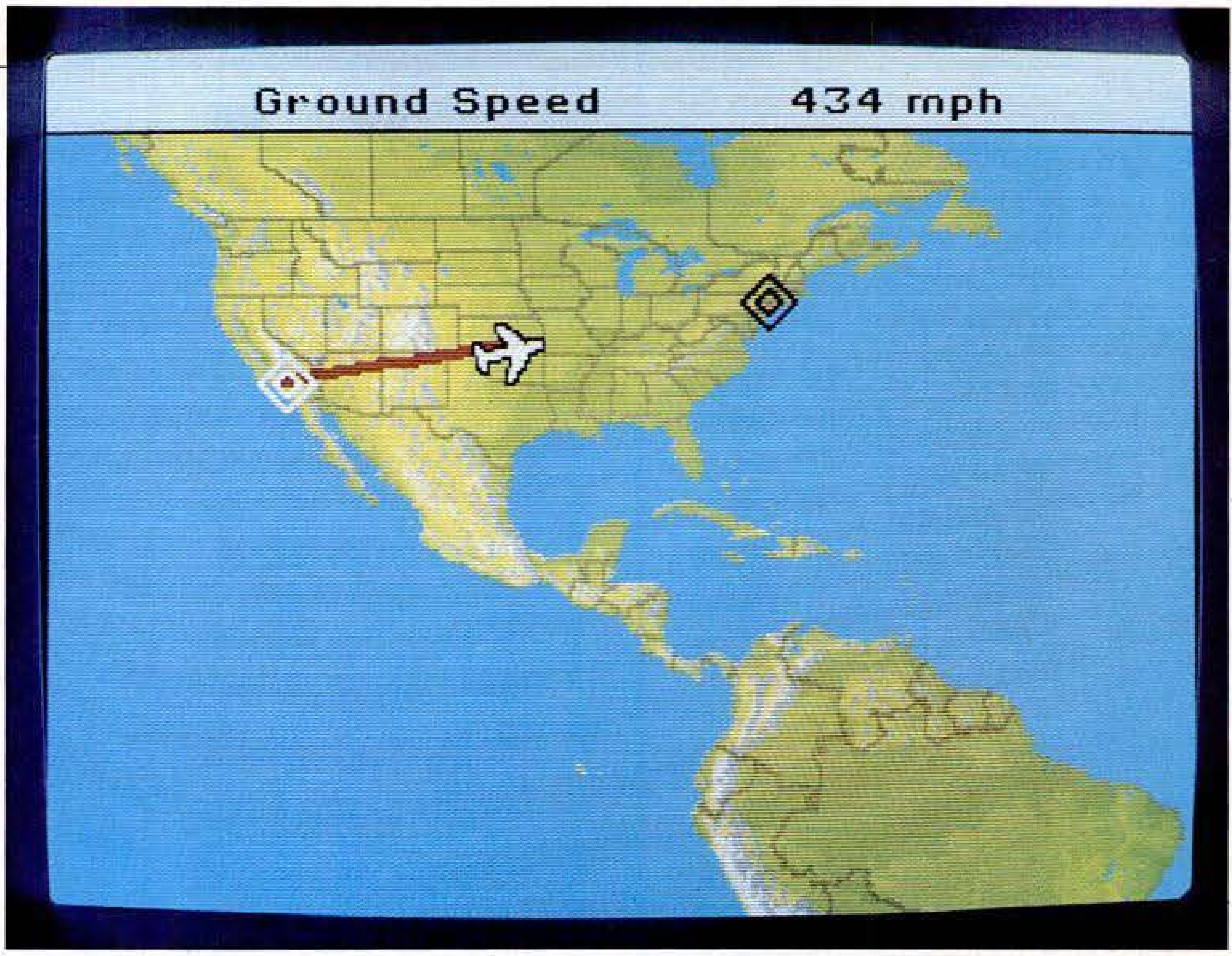
an order. Not so with a system called TV Answer, which uses a hand-held remote to link viewers to merchandisers.

A transmitter at the TV Answer signal processing center sends a query: "Would you like to order the diamond ring just advertised?" The viewer presses a button on the remote unit, and the response is picked up by a box on top of his TV set (see drawing).

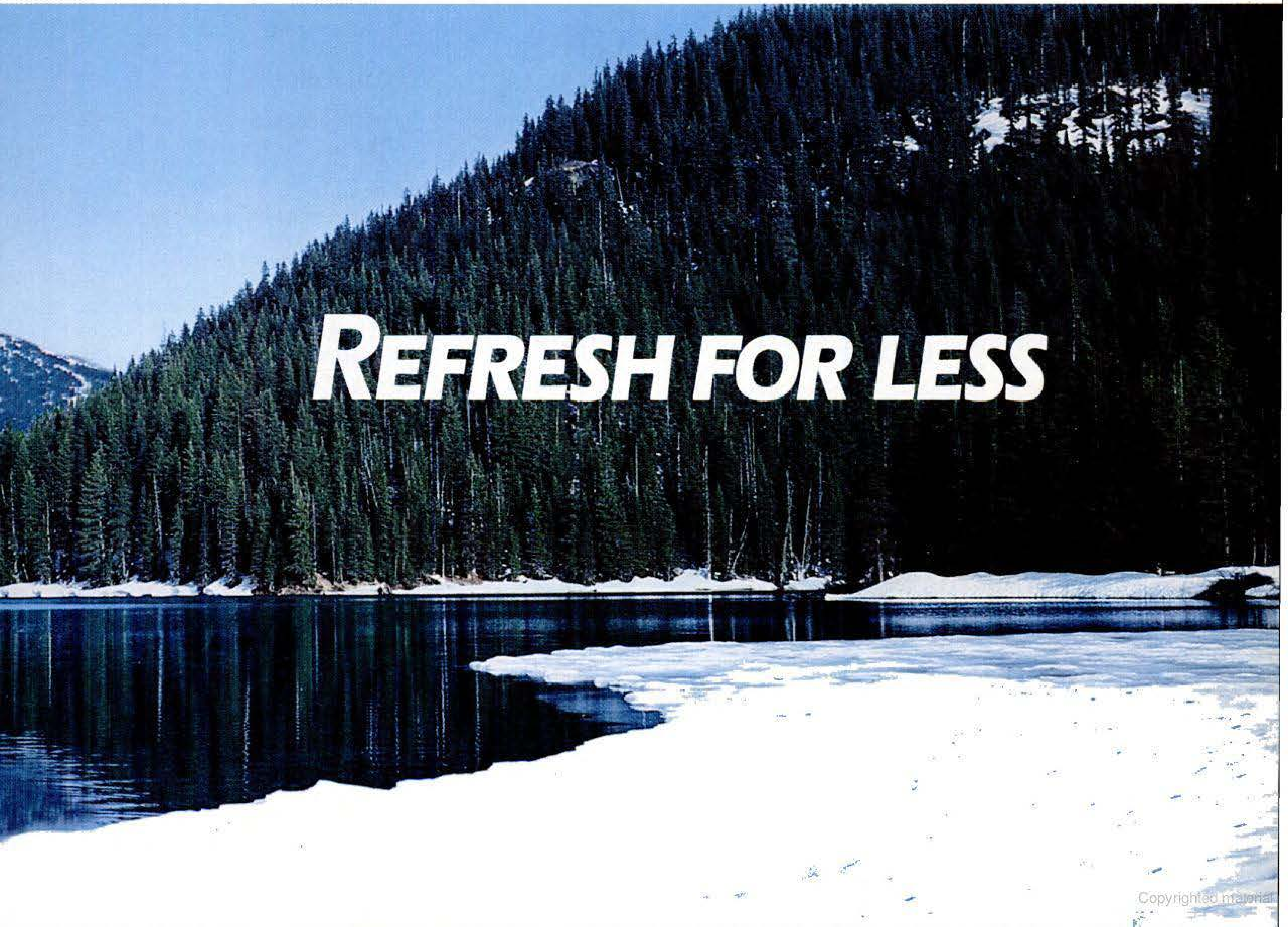
With the possibility that thousands of viewers will punch their remotes at the same time, the system uses a technique called slotted timing to sort the orders: Each box holds your order and waits to send it as a burst of data after receiving a trigger signal from the repeater site. Because the data bursts are less than 50 microseconds long, the theoretical capacity of the system is 772,000 responses per minute, according to TV Answer.

The company, based in McLean, Va., is now testing its system in 600 local homes. The major hurdle will be convincing the FCC that the system doesn't interfere with channel 13, which occupies an adjacent frequency. The agency is expected to rule on the matter this summer.



An Airshow map displays a Qantas route from Los Angeles to New York. Computer-generated graphics on cabin movie screens may include ground speed and other flight information (see text).

Meanwhile, New York-based ACTV Inc. is testing an experimental interactive system in 300 Springfield, Mass., homes. ACTV viewers can do more than simply respond to questions: They can also change the content of programs—choosing camera angles during a sporting event, for example. Like TV Answer, ACTV works with a remote control—it sends signals to a converter in the cable box. The cable compa-



ny simultaneously transmits all of the programming options that are available, so there's no need for two-way communication.

Flight information

The map of southeast England projected on the movie screen came to life as the Qantas 747 roared down the runway at Heathrow Airport. I watched as an aircraft symbol crawled over the yellow land and crossed the blue English Channel, trailing a red flight-path line. High over Europe, a text display appeared: Ground Speed 570 mph, Altitude 29,000 feet, Outside Air Temperature minus 40 degrees, Distance from Departure 155 miles, Time to Destination 13:35 hours.

Hours later, I glanced up and saw we were over the Caspian Sea, where we looped around the Iranian border to avoid hostile airspace. A map showing our cross-continental route alternated with smaller ones giving more details. After crossing the Himalayas and Burma, I watched the altitude reading drop on our descent into Bangkok.

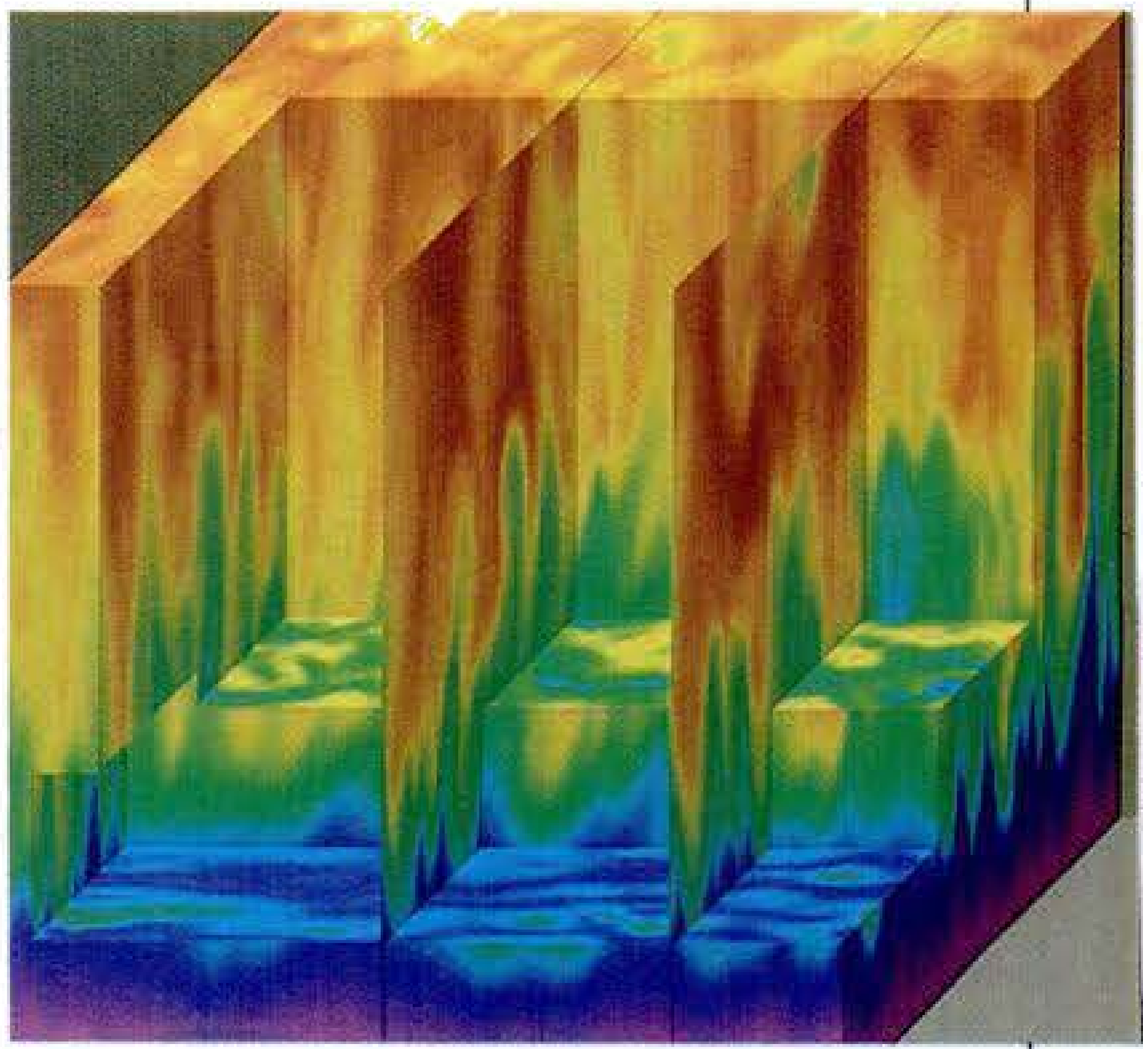
The cabin video system, Airshow, adds a new dimension to air travel, especially on long-haul flights like a non-stopper to Bangkok. The animated graphics fill the screen between the three movies and do much to relieve boredom.

"Hundreds of digitized maps covering the entire world are stored in a computer," says Peter Shannon, senior electronics engineer for Qantas. The computer receives information from the aircraft's navigation systems, calls up the appropriate map from its memory bank, and displays it on the overhead projectors. "Maps are changed automatically to match progress along the route," says Shannon.

Eight airlines are using Airshow. "Our system is customized for each airline," explains Richard Salter Jr., vice president of engineering at Asinc Inc., the Tustin, Calif., company that makes Airshow. "Special data bases can store over 2,000 points of interest—cities, mountain peaks, and other terrain features—then spot and name them on the close-up map displays. Passengers thus know what they're looking at outside the window."

Slice and dice

Scientists and engineers who use Macintosh II computers have a new tool for visualizing complicated data. Developed by Spyglass, Inc., of Champaign, Ill., a set of four programs converts data into color graphics (see photo). That gives scientists a "vivid, meaningful picture of what those rows and columns of numbers describe," says astrophysicist Brand Fortner, director of research and development for Spyglass.



Spyglass Dicer displays 3-D data as a color cube; users cut parts away to reveal the data inside.

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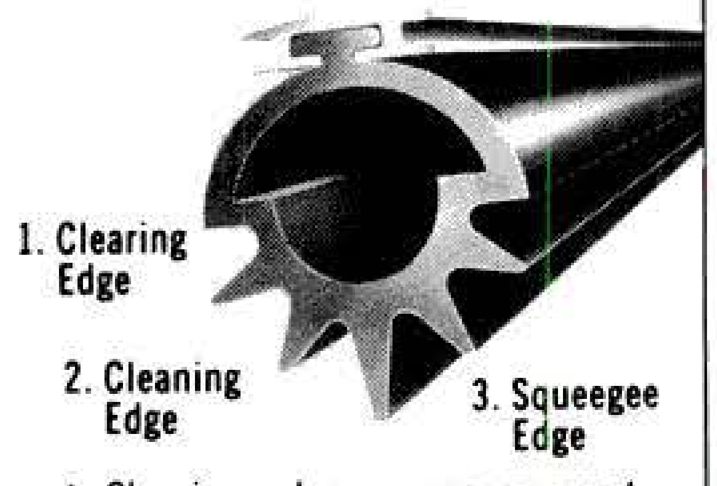

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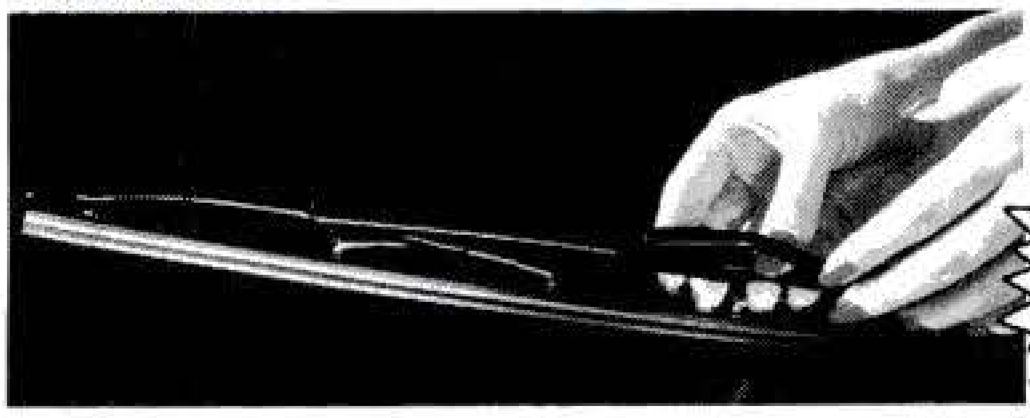

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Foiling terrorists

Vexed by the bombing of Pan Am Flight 103 over Lockerbie, Scotland, the FAA has ruled that U.S. airlines must install explosives-detection systems by 1994.

Currently airlines screen passengers and carry-on luggage using X-ray machines and metal detectors. FAA regulations also require airlines to X-ray baggage on international flights. X-ray systems such as the Sycoscan detector, made by Schlumberger Industries of France, provide detailed images of concealed weapons (photo). But the next generation of detectors will bombard luggage with neutrons, not X-rays.

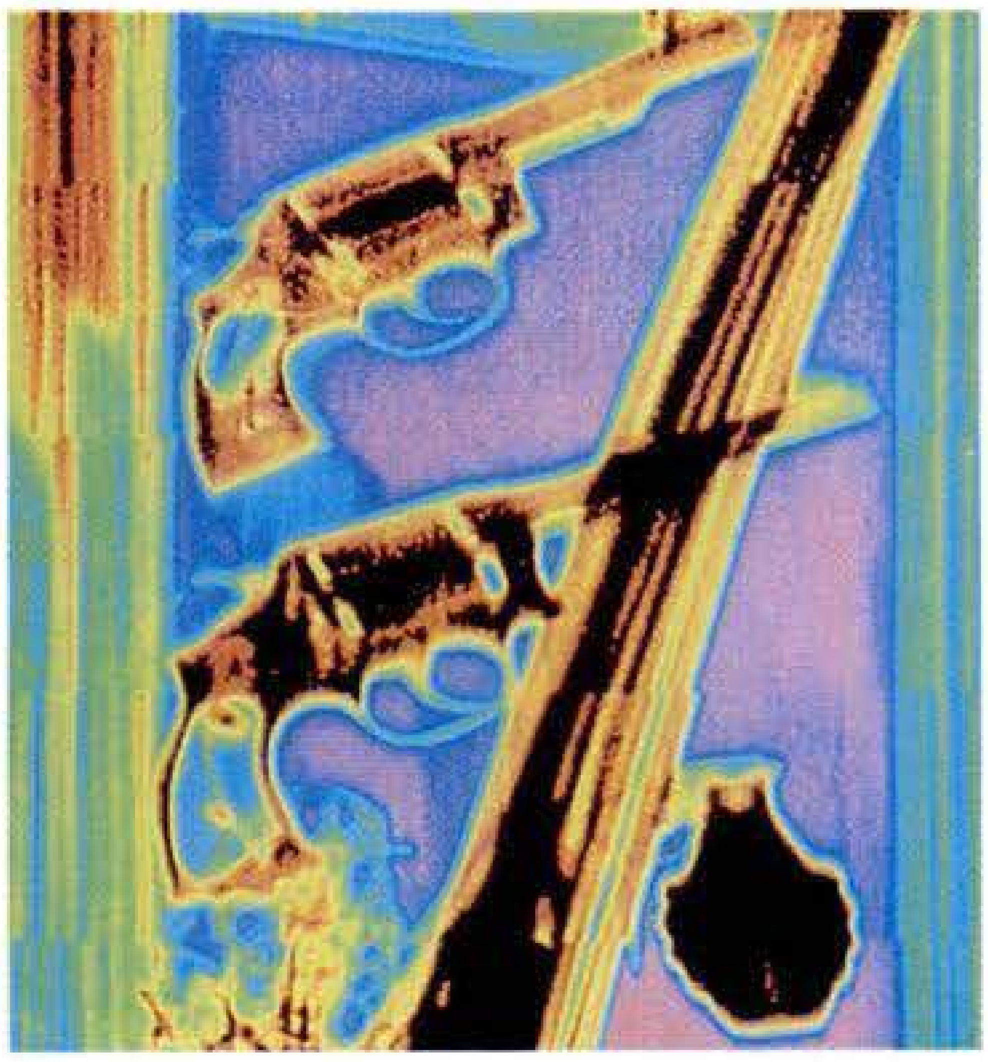
Thermal-neutron activation (TNA) systems made by Science Applications International Corp. have already been installed at Miami International Airport and New York's Kennedy International Airport. Inside a 10-ton machine, luggage strafed by low-energy neutrons emits gamma rays. The rays given off by nitrogen (used in all explosives) are easy to detect, and a neural-network computer compares the emission patterns with profiles of known explosives ["Brain-style Computers," Feb. '89].

While no other system has yet proven more effective, TNA does have critics. Some airlines complain that TNA systems are too expensive ($750,000 to $1 million), too unreliable (wool, nylon, and silk sometimes contain enough nitrogen to trigger false alarms), too slow, too bulky, and might not be able to detect small amounts of explosives.

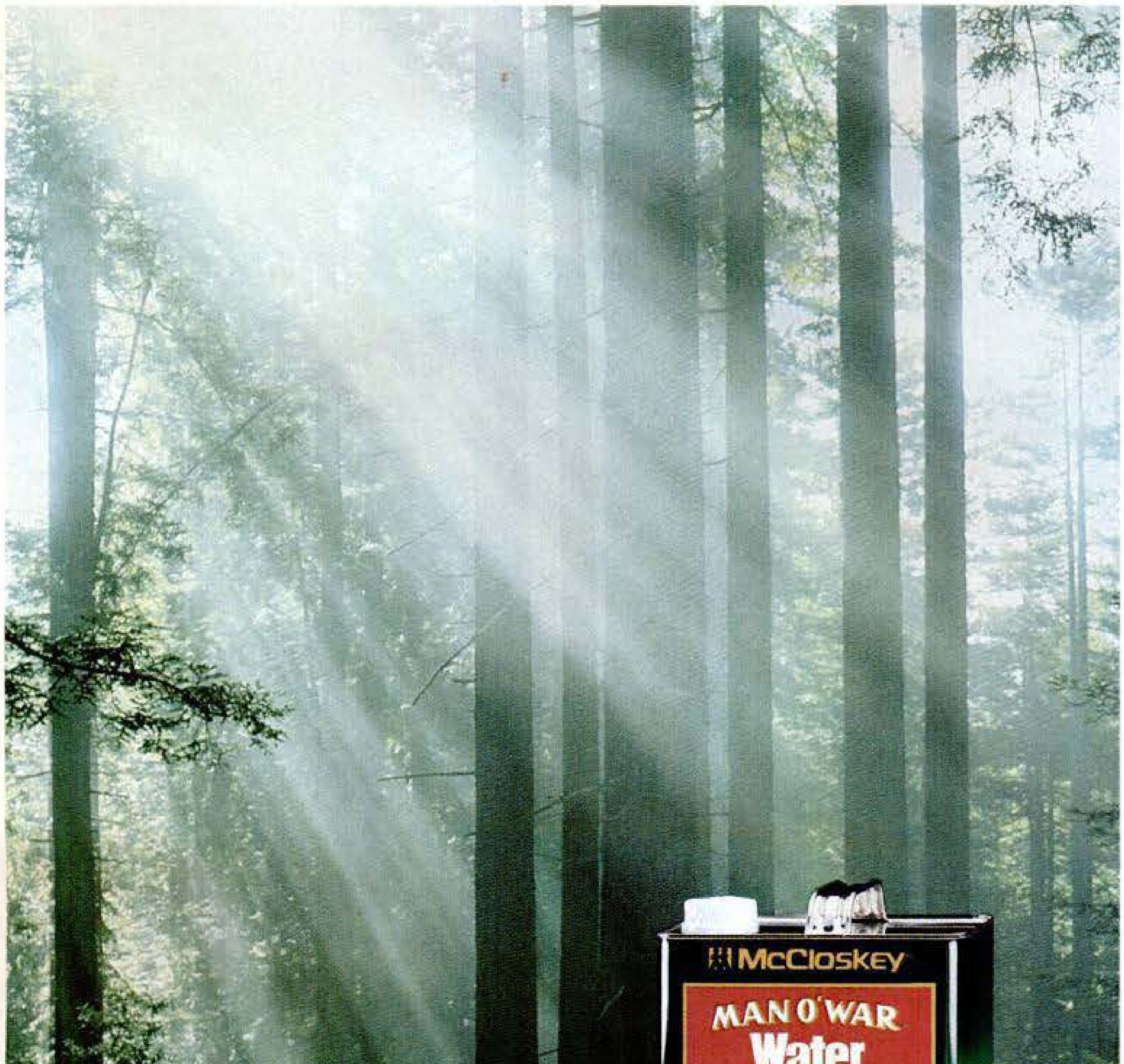
One possible alternative to TNA is FNA, or fast-neutron activation, in which high-energy neutrons react with carbon and oxygen as well as nitrogen. Explosives alone contain high densities of nitrogen and oxygen and low densities of carbon. The company Société d'Etudes et Réalisations Nucléaires (SODERN) and the French atomic energy commission have developed a pulsed neutron generator that checks bags with an FNA test when the TNA test is inconclusive. SODERN claims its system can process up to 1,200 bags per hour, detecting explosives 99.8 percent of the time.

DAT update

A bill requiring digital audio tape recorders to contain a Serial Copy Management System circuit, which prevents a DAT machine from making third-generation copies (copies of copies) of original material, has been introduced in the Senate as expected. But unexpectedly, and unlike its passage in the House months ago, the bill has provoked a battle over artists' royalty payments. Result: Consumer DATs are once again on hold for the U.S. market, and no one knows how long the stalemate could last. PS



Sycoscan's X-ray system spots hand guns and a grenade hidden in a freight container.



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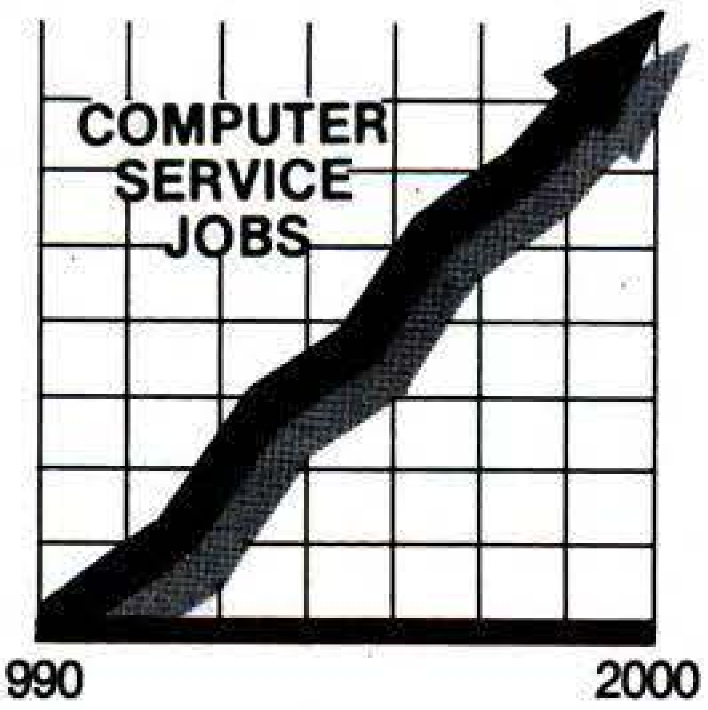

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Jobs for computer service technicians will almost double in the next 10 years, according to the latest Department of Labor projections. For you, that means unlimited opportunities for advancement, a new career, or even a computer service business of your own.

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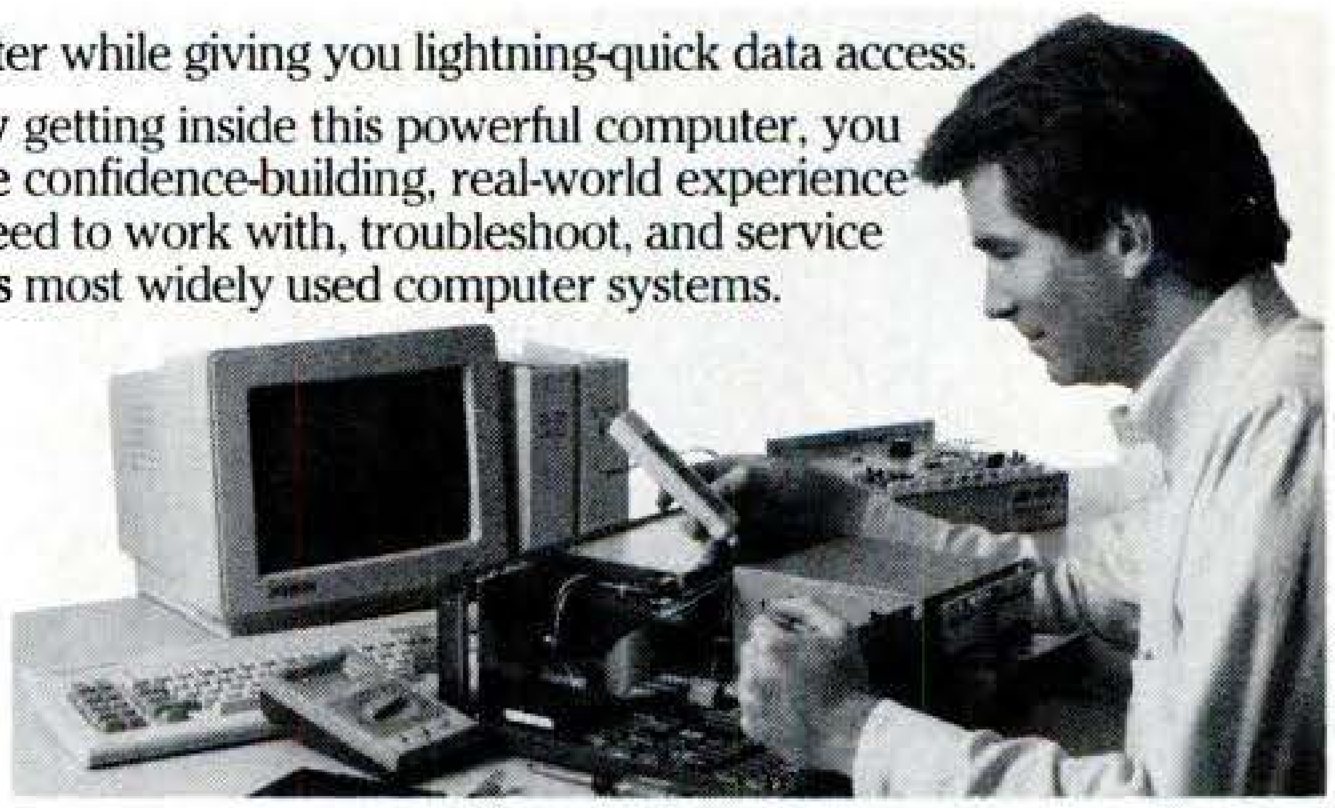

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Home Newsfront

By V. ELAINE GILMORE *with Timothy O. Bakke*

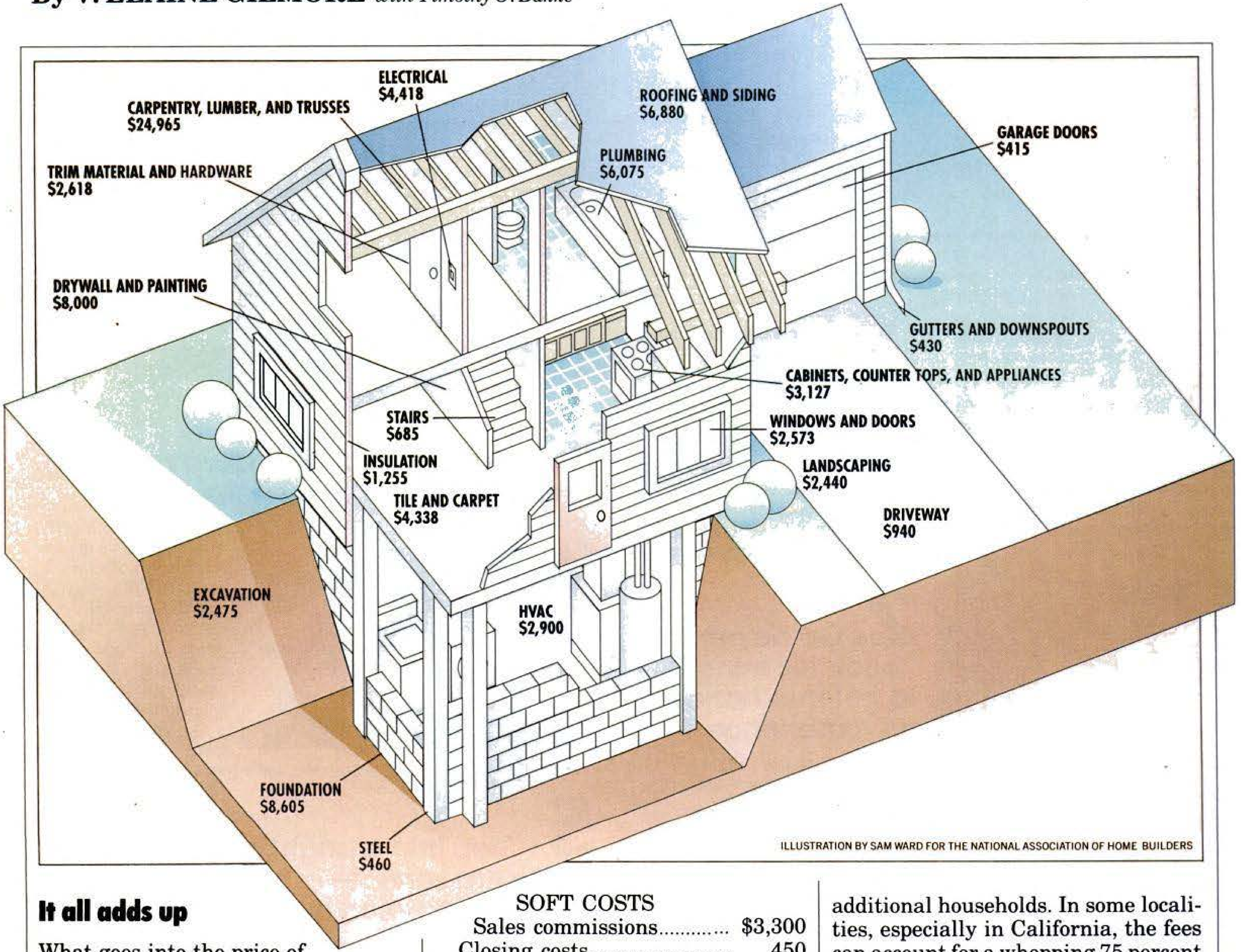

ILLUSTRATION BY SAM WARD FOR THE NATIONAL ASSOCIATION OF HOME BUILDERS

It all adds up

What goes into the price of a new house? The National Association of Home Builders got this breakdown from Richard Brown, president of Cambridge Homes in Lake County, Ill., a Chicago suburb. The house has four bedrooms, a full basement, and a two-car garage. Construction costs (as itemized above) plus village permit fees ($6,884), overhead ($5,160), and interest ($1,200) add up to $96,843—about 60 percent of the $159,900 selling price. Remaining costs break down like this:

LAND AND LOT DEVELOPMENT	
Raw land	$17,000
Impact fees	5,195
Engineering and soil tests	995
Mass earthwork	1,588
Sewers and water mains	3,257
Streets, curbs, and gutters	4,620
Overhead	750
Interest	4,500
Miscellaneous	752
Subtotal	$38,657

SOFT COSTS	
Sales commissions	$3,300
Closing costs	450
Advertising and marketing	4,200
Administrative costs, profit	13,406
Warranty expense	1,000
Contingency	2,044
Subtotal	$24,400
TOTAL PRICE	$159,900

The item that varies most across the country is the cost of land and lot development, according to Michael Carliner, staff vice president for economics and housing policy at the NAHB. "It ranges from fifteen percent to thirty-five percent of the total," he reports. "Within that, typically forty percent goes for buying raw land, forty percent is development cost (like putting in streets and sewers), and about twenty percent is fees."

Fees go for basics like permits and inspections. But increasingly, they also are imposed to cover the cost of infrastructure, primarily roads and schools, not on the site but necessitated by the additional households. In some localities, especially in California, the fees can account for a whopping 75 percent of the land cost, Carliner reports.

"Such fees are most common in California and Florida," he says. "But the trend is spreading. It's a popular way of funding what used to be paid through bonds and real-estate taxes."

In some areas these fees have been successfully challenged in court on the basis that they are illegal taxes. Nevertheless, Carliner expects them to proliferate. In California, after a municipality lost a case, the state legislature passed a bill allowing such fees but limiting the amount.

New wood preservative

A couple of years ago, a new product called Tim-Borized wood began appearing in lumber yards ["Building with Borate," March '88]. This insect- and decay-resistant lumber gets its protection from a preservative based on sodium borate, a first cousin to borax.

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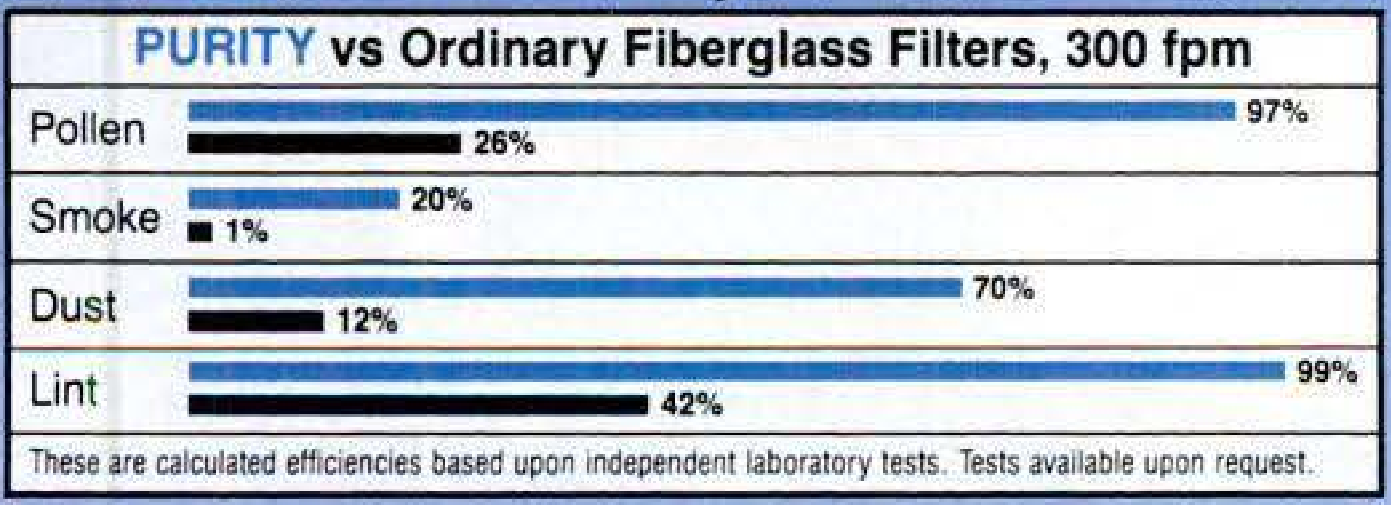

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Home Newsfront

Now there's a borate-base preservative you can buy and use at home. It's called Bora-Care, and it's made by Perma-Chink Systems.

Tim-Bor, the brand name of the pesticide in the lumber and in Bora-Care, protects wood from termites, carpenter ants, wood-boring beetles, and decay-promoting fungi. It kills critters already in the wood and protects it from further infestation. Boron, a principal constituent, is toxic to fungi, but researchers are not sure why it kills insects. The most widely accepted theory postulates that it attacks beneficial microbes in their guts, causing the bugs to starve.

The Tim-Bor used in Tim-Borized wood is formulated using water as the carrier. When heated it penetrates green wood readily. But it is unsuitable as an on-site treatment because it will not penetrate dry lumber. Bora-Care solves the problem by using glycol as the carrier. It penetrates dry lumber to the center, says Perma-Chink.

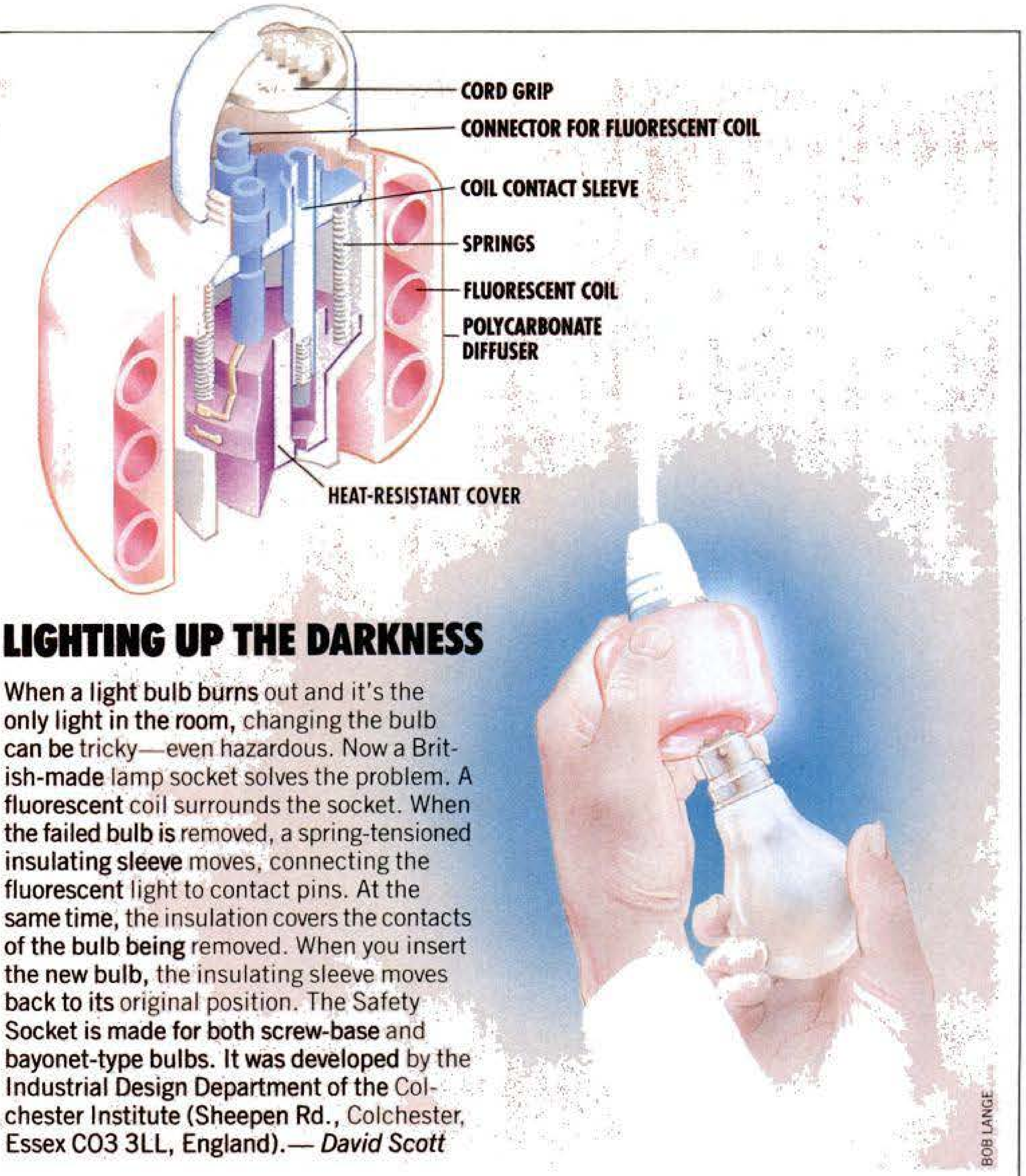
Bora-Care, like Tim-Bor, does not change the color or working characteristics of the wood. To use it add an equal volume of water, then apply (to bare wood only) with a sprayer or a brush, or you can dip the wood.

Bora-Care can be used nearly anywhere, but consider this: The preservative will leach out if exposed to water. Thus it is not suitable for lumber in contact with the ground. If used on exterior surfaces you must coat the treated wood with a water-repellent finish.

If you have a termite or beetle infestation, it is recommended that you contact a professional pest-control company. "They can best apply the product and advise on an integrated method of control," he says.

Bora-Care does not emit noxious fumes when it's being applied, but you should provide ventilation when using it inside. If used outside, plants and soil should be protected with plastic. And because of the glycol carrier, Bora-Care, unlike Tim-Bor, is toxic to animals if ingested. Keep it away from children and pets.

Bora-Care sells for $60 a gallon, enough to treat 800 board feet. Perma-Chink Systems, 1605 Prosser Rd., Knoxville, Tenn. 37914.



LIGHTING UP THE DARKNESS

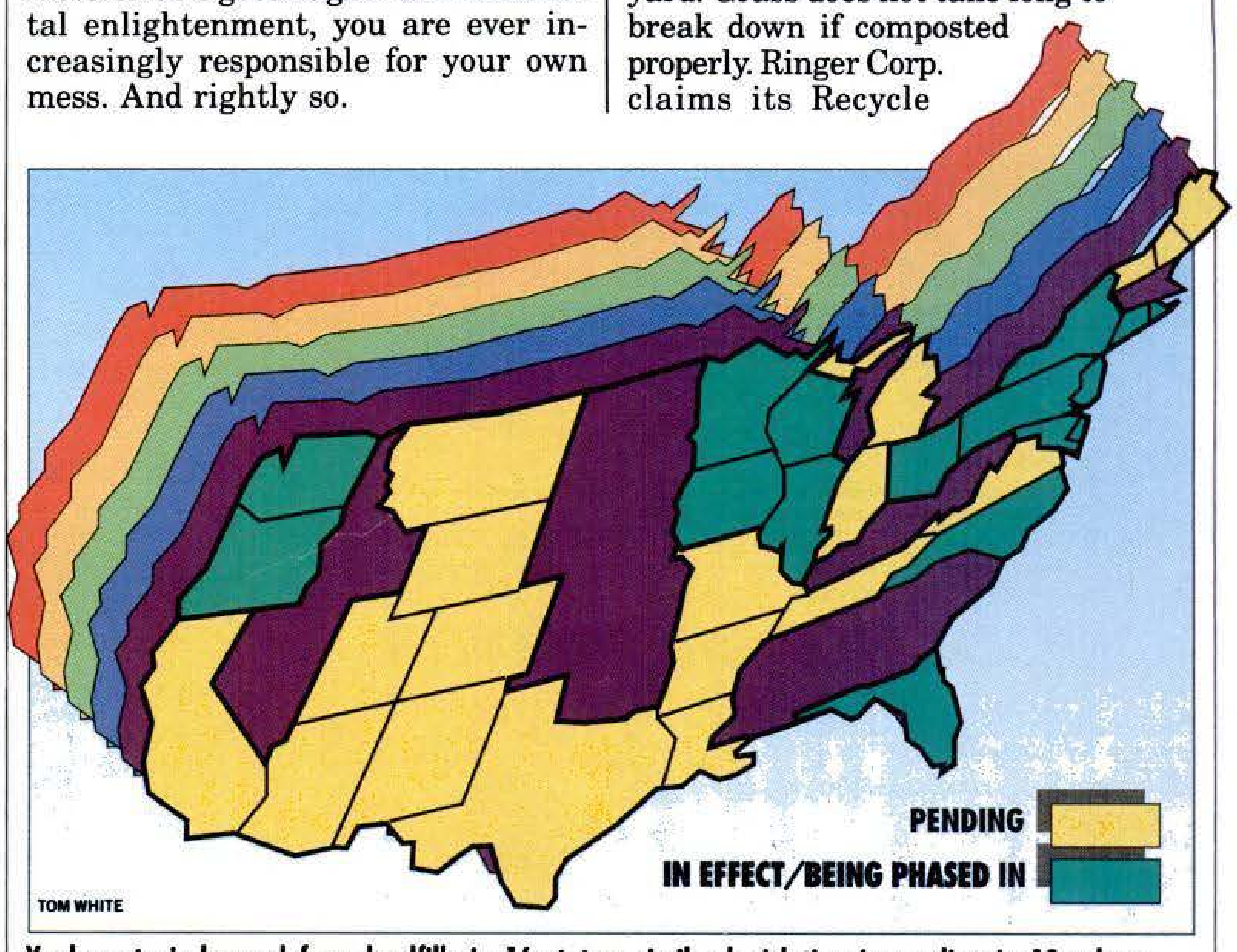
When a light bulb burns out and it's the only light in the room, changing the bulb can be tricky—even hazardous. Now a British-made lamp socket solves the problem. A fluorescent coil surrounds the socket. When the failed bulb is removed, a spring-tensioned insulating sleeve moves, connecting the fluorescent light to contact pins. At the same time, the insulation covers the contacts of the bulb being removed. When you insert the new bulb, the insulating sleeve moves back to its original position. The Safety Socket is made for both screw-base and bayonet-type bulbs. It was developed by the Industrial Design Department of the Colchester Institute (Sheepen Rd., Colchester, Essex CO3 3LL, England).—*David Scott*

Yard-waste wrap-up

It used to be that Saturday's grass clippings went out neatly packaged in trash bags with Monday morning's garbage. The same was true of raked leaves or the hedge's pruned limbs.

Not anymore. In most states you can't—or soon won't be able to—leave yard debris curbside for the local sanitation team to whisk away (see map). Landfills cannot afford the space anymore. In this green age of environmental enlightenment, you are ever increasingly responsible for your own mess. And rightly so.

What to do? If you have a bagging lawn mower, you can collect and compost the clippings in a corner of the yard. Grass does not take long to break down if composted properly. Ringer Corp. claims its Recycle



Yard waste is banned from landfills in 16 states; similar legislation is pending in 19 others.

Kit, which includes a heavy-duty reusable plastic bag and an additive containing non-pathogenic cellulose-degrading microorganisms, speeds the process to 10 to 30 days. It costs $10.

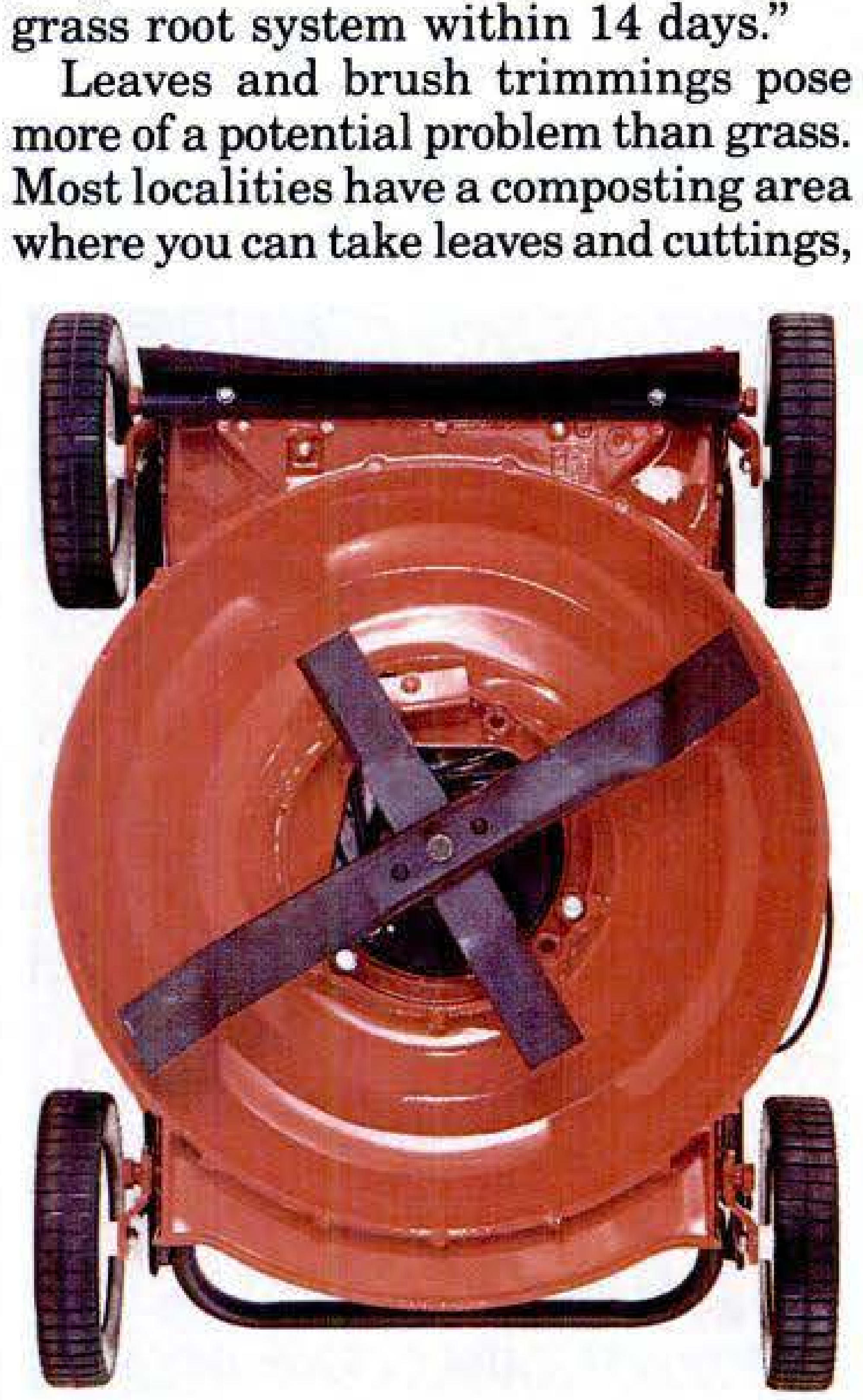
You can also mulch. First introduced in the late 1960s, mulching lawn mowers soon fell out of favor. Now they are back. Various mowers use add-on kits, special deck designs, or multiple cutting blades, all without discharges so the grass clippings are cut up small and deposited onto the lawn from under the deck.

With any of these mulching mowers it is most important that you not let the grass get more than a few inches tall or the clippings will clump.

You can also forego the mulching mower and just discharge the cut grass back onto the lawn, but you have to be prepared for the aesthetics of such a method: Your lawn may look brown for a week or so. If you mow often enough though, that may not be a problem.

The idea of returning grass clippings to the soil is a good one. To quantify how good, Garden Way/Bolens and the Rodale Research Center in Emmaus, Pa., are conducting a three-year test, comparing the value of mulching clippings versus bagging and removing them on otherwise identical grass plots. Similar tests performed by Michigan State University in the early 1970s showed that with mulching, nitrogen and other nutrients "were leached and/or released from the clippings into the soil and absorbed by the grass root system within 14 days."

Leaves and brush trimmings pose more of a potential problem than grass. Most localities have a composting area where you can take leaves and cuttings, but you are responsible for getting them there. Or, if you don't have that many leaves, you can till them into the soil before winter sets in. In both cases, a shredder or chipper of some kind, either electric- or gas-powered, would probably be necessary to reduce volume. For a small amount of leaves, you might use a yard blower/vacuum to grind them up. Small electric shredders take leaves and branches up to about an inch or so in diameter; larger chipper/shredders, which can cost up to $1,000, take branches up to three inches in diameter.



Mulching mowers from Simplicity (shown) and Homelite use two blades to chop grass clippings into fine particles.

SOME SOURCES FOR MULCHING MOWERS

Deere & Co., John Deere Rd., Moline IL 61265; **Garden Way/Bolens/Troy Built,** 102nd St. & 9th Ave., Troy NY 12180; **Homelite**, 14401 Carowinds Blvd., Charlotte NC 28241; **Simplicity Manufacturing,** Box 997, Port Washington WI 53074; **Snapper Power Equipment,** Box 777, McDonough GA 30253; **Toro Co.**, 8111 Lyndale Ave., S., Minneapolis MN 55420

SOME SOURCES OF CHIPPERS/SHREDDERS

Amerind-Mackissic, Box 11, Parker Ford PA 19457; **Garden Way/Bolens/Troy Built; Lescha North America,** Box 266, Bolton LOP 1A0, Ont., Canada; **Tornado Products,** N114 W18605 Clinton Dr., Germantown WI 53022; **Vornado Power Products,** 2 Main St., Melrose MA 02176; **W-W Grinder,** Box 4029, Wichita KS 67204

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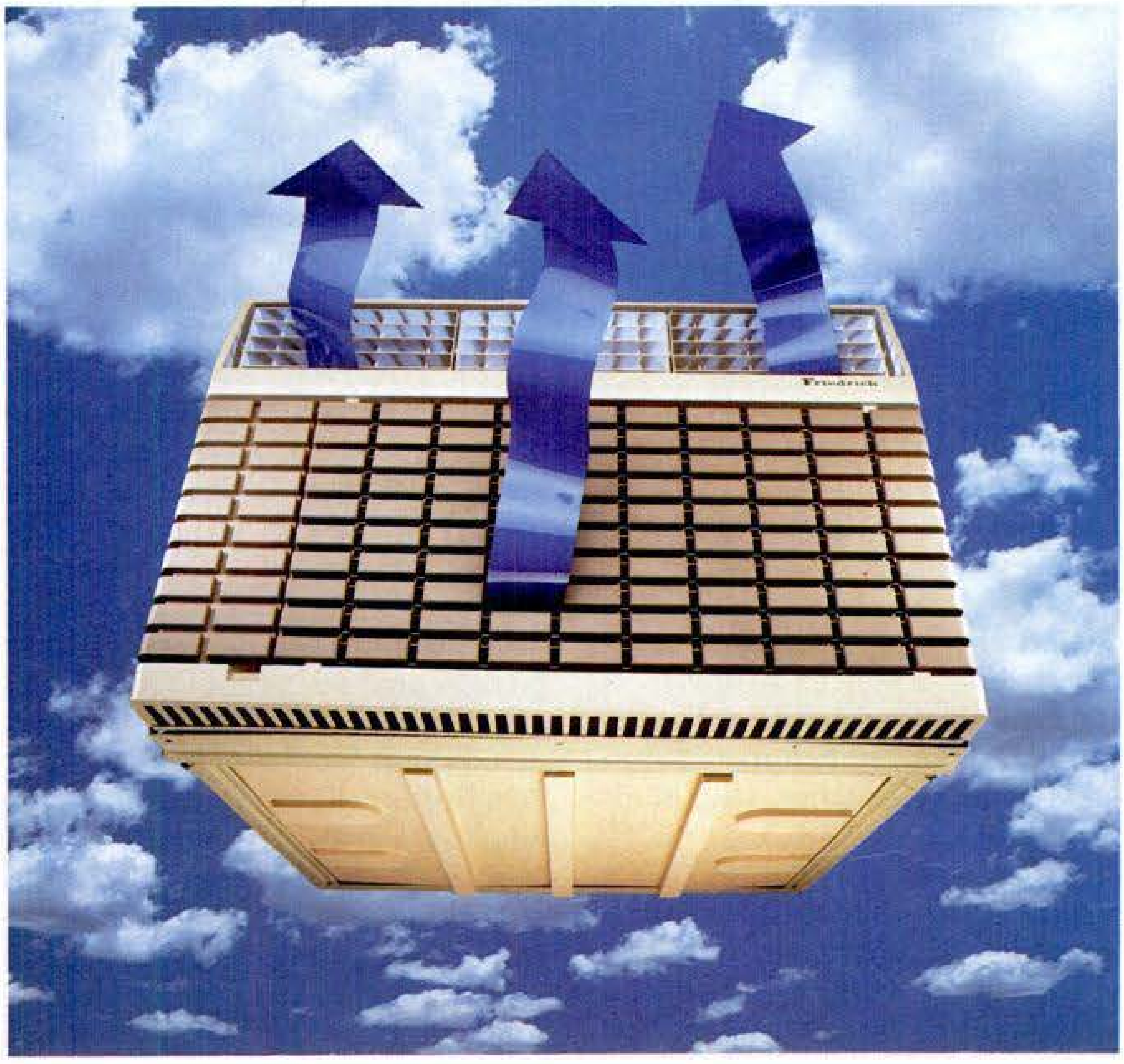
Popular Science
JULY 1990

OZONE-FRIENDLY COOLING

A/C without CFCs



The organic chemicals called CFCs were once thought to be ideal refrigerants and environmentally benign. Now we know that they weaken Earth's protective ozone shield. But the chemistry that gave birth to CFCs is coming up with replacements that will limit the damage.

"The ozone hole." This phrase has joined "global warming," "acid rain," "toxic waste," and similar epithets in the growing lexicon of environmental hazards. And as with these other hazards, the global community is learning to use new technology to avert catastrophe.

The "hole" is both a phenomenon and a symptom—a warning sign, atmospheric scientists agree. Since 1984, satellite and ground-station monitoring have revealed that it develops each spring in a kind of bull's-eye centered over Antarctica. The hole appears in the ozone layer, beginning about 10 miles above Earth's surface.

Ozone concentrations are measured in something called Dobson units. Normal for the stratosphere is around 350; in 1987 the level over the Antarctic fell to an all-time low of 109.

Why is this important, perhaps as weighty as the threats from global warming, acid rain, and toxic wastes combined?

Ozone, the unstable triatomic form of oxygen, is an irritant at Earth's surface, capable of damaging lungs and eyes. But in the stratosphere, it blocks out the shortest wavelengths of ultraviolet light from the sun, shielding all life on Earth from potentially lethal radiation.

The development of the ozone hole over Antarctica, and recent evidence that conditions are ripe for similar ozone depletion over the North Pole and northern latitudes, means that this barrier is being penetrated.

The consequences of an unabated attack on the ozone layer are, like other projections of environmental changes, speculative. But the EPA estimates that for every one percent diminution of ozone in the stratosphere there will be a two percent increase in short-wavelength ultraviolet radiation to reach Earth's surface.

This is high-energy radiation; in the electromagnetic spectrum, the shorter the wavelength, the higher the energy. And it is capable of effecting harmful changes in the genetic material—DNA. One of the most predictable results of such radiation bathing life on Earth's surface is an increase in human skin cancers, especially the most malignant kind, melanomas. Biologists fear that a substantial increase in high-energy UV radiation could also disrupt the aquatic food chain by killing off certain species of plankton. Food crops could be adversely affected.

Why is the ozone layer changing? There is now no doubt as to the na-

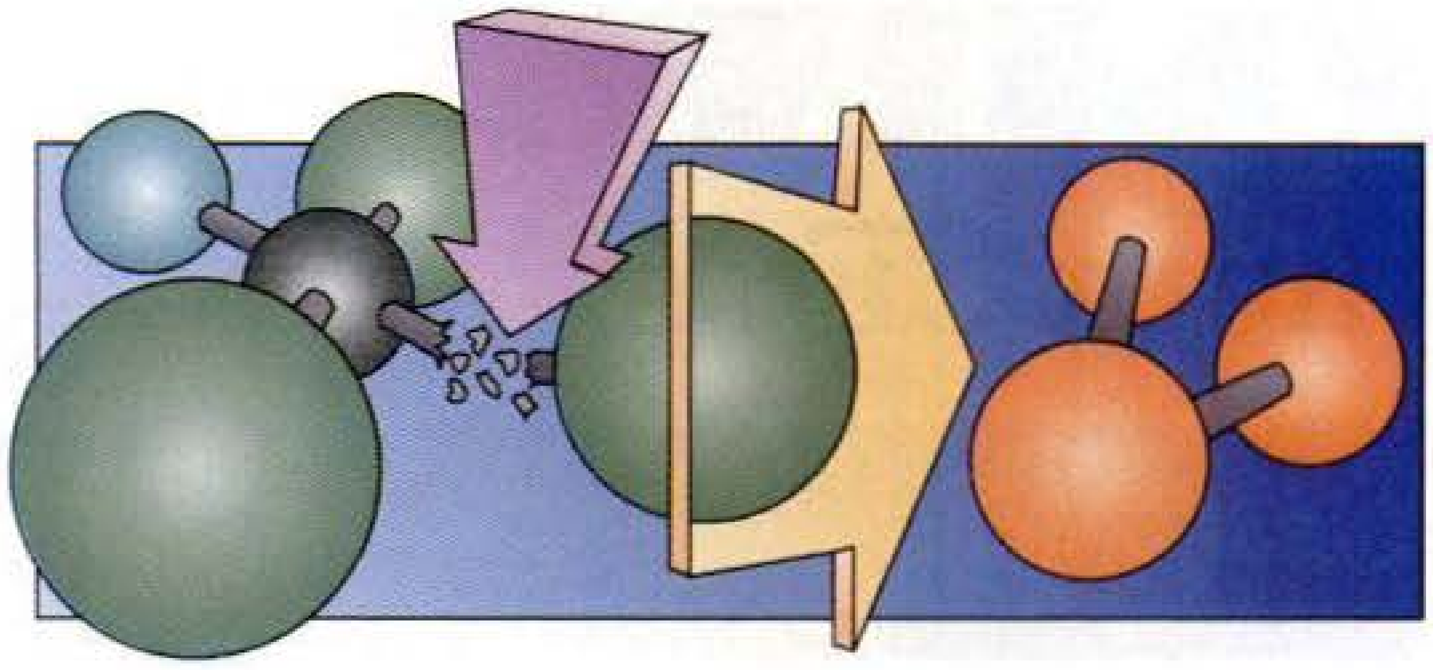
THE CHEMICAL OFFENDERS AND REPLACEMENTS

CHEMICAL	ATMOSPHERIC LIFE (YEARS)	OZONE DEPLETION POTENTIAL (a)	GLOBAL WARMING POTENTIAL (b)	MAJOR USES
CFC-11 [CCl3F] TRICHLOROFLUOROMETHANE	64	1.0	0.32	REFRIGERANT, FOAM BLOWING
CFC-12 [CCl2F2] DICHLORODIFLUOROMETHANE	108	1.0	1.0	REFRIGERANT, AEROSOL
CFC-113 [CCl3CF3] TRICHLOROTRIFLUOROETHANE	88	0.8	0.49	SOLVENT CLEANING, DRY CLEANING
HCFC-22 [CHClF2] CHLORODIFLUOROMETHANE	22	0.05	0.07	RESIDENTIAL COOLING
HCFC-123 [CHCl2CF2] DICHLOROTRIFLUOROETHANE	2	0.01	0.01	REPLACEMENT FOR FOAM BLOWING
HFC-152a [CH3CHF2] DIFLUOROETHANE	2	0	LESS THAN 0.1	REPLACEMENT FOR REFRIGERATION
HCFC-141b [CCl2FCH3] DICHLOROFLUOROETHANE	10	0.03	0.05	REPLACEMENT FOR FOAM BLOWING
HFC-134a [CHFCF3] TETRAFLUOROETHANE	8	0	LESS THAN 0.1	REFRIGERANT

(a)—based on CFC-11 (b)—based on CFC-12

ture of the attacker. It goes by the generic term of CFCs, short for chlorofluorocarbons. They share certain basic chemical attributes, although many variations on the formula exist, usually differentiated by number.

In 1974 F. Sherwood Rowland and his colleague at the University of California, Irvine, Mario Molina unraveled the complex chemical reactions by which CFCs could rise to the stratosphere, persist for a century or more, and there release chlorine atoms that gobble up ozone molecules at a fantastic rate ["The Man Who Knew Too Much," Jan. '89].



How CFCs destroy ozone in the stratosphere: Ultraviolet light (purple) breaks a bond in the CFC molecule, releasing a chlorine atom (green), which then attacks the ozone molecule (red).

The ozone-thinning created by the CFCs is not limited to the polar regions, although certain atmospheric conditions there are especially conducive to the creation of "holes." For example, Rowland says, "In the late Antarctic spring, air that hasn't been depleted of ozone moves in, and the ozone hole is shipped elsewhere, leading to a thinning of the ozone layer over temperate latitudes."

CFCs are among the most ubiquitous of all man-made chemical compounds. Originally considered harmless, they were crafted to suit a whole spectrum of uses (see table). Here are some of the current applications for specific variations of CFCs:

- CFC-11 creates the tiny bubbles in foam products. It is also used as a refrigerant.
- CFC-11 and CFC-12 are used as propellants for aerosols such as hair sprays and deodorants. That use has been banned with certain exceptions in the United States, but continues elsewhere.
- CFC-12 is the working fluid in refrigerators and car air conditioners.
- CFC-113 is widely used to clean electronic circuit components and is used in dry cleaning.

In 1988 the use of CFCs worldwide broke down as follows, in millions of pounds: as refrigerants, 750; as foaming agents, 730; in aerosols, 480; as cleansers, 480; in all other uses, 100.

Of course, it is only when CFCs escape into the atmosphere that they become a threat to the environment. And some CFC applications leak a disproportionate share. For example, although car air conditioners contain less than half of all CFCs, they account for about three-quarters of CFC emissions. Projections for the amount of CFC-12 needed to replace leaks in 1990 are 90.1 million pounds for vehicles; 21.5 million for retail food refrigeration; 8.6 for chillers, including home air conditioners; and 0.6 for home refrigeration.

Ever since the role of CFCs in the destruction of the ozone layer became clear, a two-pronged approach to coping with the problem has emerged.

One is simply to restrict, by international agreement, the amount of CFCs manufactured worldwide. The Montreal Protocol of 1986 mandated a CFC production freeze, followed by a total phase-out by the year 2000. Says Rowland, "As an international agreement it is almost without precedent because it actually proposes to reduce the emission of a pollutant." But he adds that the CFCs we have already added to the atmosphere will continue to damage the ozone layer because their effects persist for decades. "Even if we act now," he says, "we can expect to see the worst stages of ozone depletion around the year 2020." The longer we delay, the further into the future that peak is pushed.

Unfortunately, the Montreal treaty has a giant loophole: It allows the developing world to increase CFC use to near the per capita level of the industrialized world. If that happens, it will push the healing of the ozone shield well into the 22nd century.

The second approach to the CFC problem is to find acceptable substitutes for them.

"It is ironic," says Dr. Leo Manzer, research manager at Du Pont, "that the most useful property of this class of chemicals [CFCs]—its inertness to chemical attack—is its greatest failing." The search for ozone-benign CFC replacements has meant building in atmospheric instability, so the replacement chemicals will break down in the lower atmosphere, before they can reach the ozone layer.

The key is the inclusion of hydrogen, which makes the molecule a target for attack by hydroxyl radicals in the lower atmosphere. Due to their shorter lifetime, these replacements will also have less opportunity to absorb infrared radiation and add to the greenhouse effect.

The most promising replacements are known generically as hydrofluorocarbons and hydrochlorofluorocarbons—or in chemical shorthand, HFCs and HCFCs. They have properties similar to CFCs, but pose little or no threat to the ozone layer.

The articles that follow in this special section detail how some of these chemicals will be used in applications where CFCs were once the norm, such as car air conditioners. They will also discuss some approaches that avoid synthetic chemicals in home cooling systems and call for inert materials to replace CFC foams

as insulation in refrigerator panels.

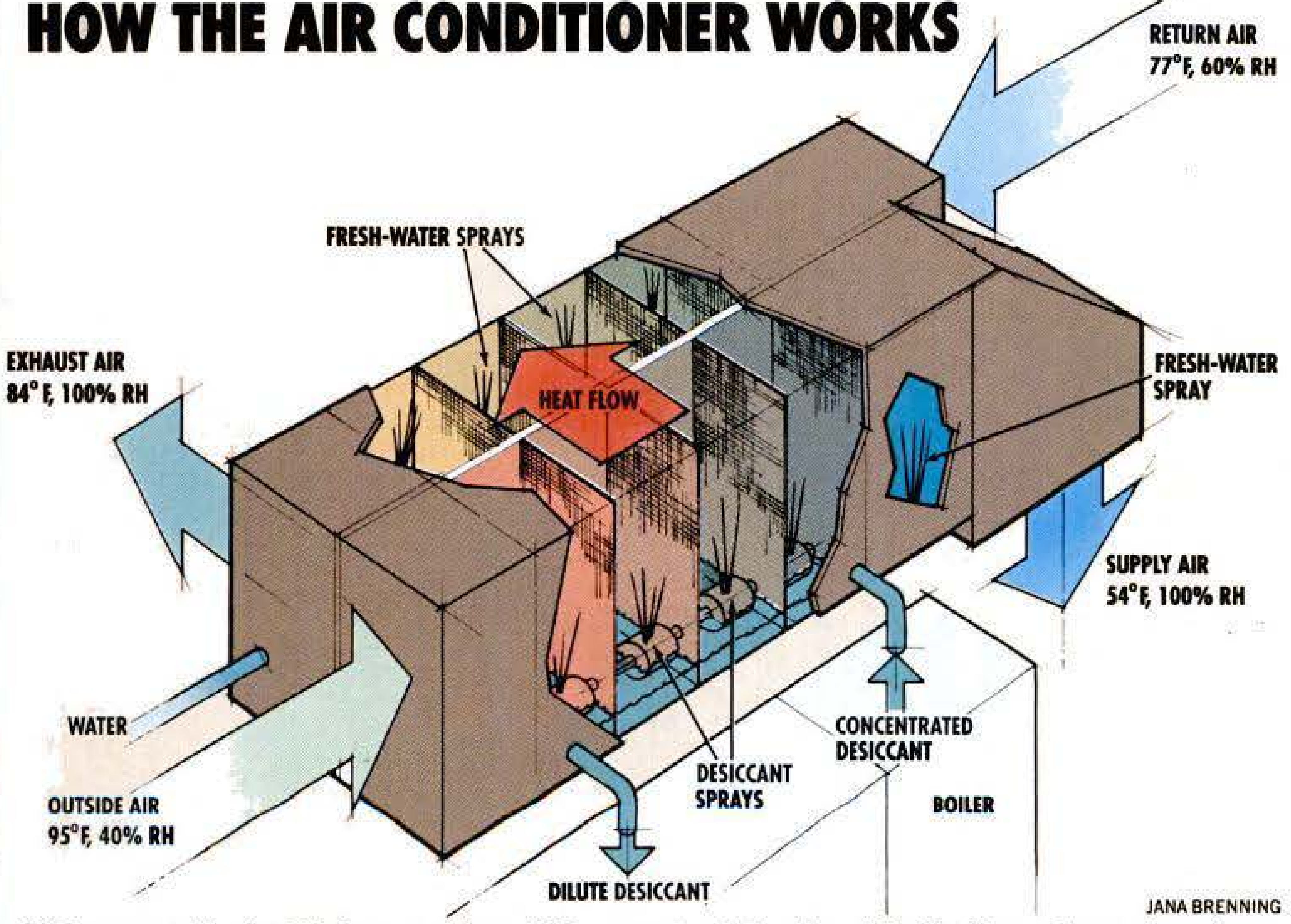
With such measures, civilization should limit, perhaps reverse, damage to the ozone shield. As Rowland says, "If we wait for the body count, it will be too late."—*Brian Nadel*

CLEAN-AIR HOME AIR CONDITIONER

Inside a green-glass building in the Arizona State University Research Park in Tempe, a machine four feet long, two feet wide, and 28 inches high hums away, drawing in the hot desert air, cooling it to 54 degrees F, and blowing it into the 1,200-square-foot laboratory.

The machine is not a conventional air conditioner; nor is it an evaporative cooler. Unlike conventional air conditioners, it has no compressor. And while air conditioners recirculate indoor air, this machine constantly brings in fresh air and exhausts stale air. Furthermore, it uses water and salt water as its working fluids. Though conventional home air conditioners use a relatively benign HCFC (see above) rather than a CFC, even HCFCs destroy some stratospheric ozone. Finally, the inventors of this machine claim it can slash air-conditioning bills by 50 percent in some climates.

HOW THE AIR CONDITIONER WORKS



JANA BRENNING

Air from outside (at 95 degrees F and 40 percent relative humidity) is blown through a chamber that is divided into sections by porous plastic plates. A desiccant solution is sprayed within each section. The air becomes drier in each because the desiccant gets progressively more concentrated. As the air dries it gains heat. But heat is constantly transferred to the return-air chamber through a heat-exchange partition. In the final chamber, fresh water is sprayed into the air, saturating it; that drops the temperature to 54 degrees. Meanwhile, air from the room is drawn through an identical sectioned chamber on the other side of the heat-exchange partition. Here fresh water is sprayed into the air, which picks up moisture; thus its temperature drops. The temperature in each water-spray section is lower than that in the opposite desiccant-spray section, so the return air removes heat—step by step—from the supply air, and exhausts the heat outdoors. The dilute desiccant flows to a regenerator (not shown). Here it is boiled at 300 degrees F, which evaporates about half of the absorbed water; steam from the boiler then is used to evaporate the rest of the absorbed water. Thus most of the energy input to the boiler is used twice.—*V.E.G.*

The air conditioner, developed by Albers Technologies Corp., is the invention of Walter F. Albers and James R. Beckman, associate professor of chemical engineering at A.S.U. It combines evaporative cooling with desiccant dehumidification. Evaporative coolers work well in dry climates: A fan draws outside air over a damp pad, where it is cooled by picking up moisture. But when the intake air is humid to start with, it can't pick up enough additional moisture to cool significantly. That's where the desiccant comes in. A desiccant is a chemical with an affinity for water. In the Albers air conditioner, a lithium bromide solution is used. "A pound of the solution can pick up five pounds of water," Beckman says.

This air conditioner is not the first to use desiccants. One that uses a revolving desiccant wheel is made by ASK Corp. (formerly American Solar King) in Waco, Texas ["High-Tech, Low-Energy Heater-Cooler," July '86]. And the Florida Solar Energy Center in Cape Canaveral is developing one that places desiccants in the attic ["Home Newsfront," Sept. '89].

The Albers air conditioner is simpler than either of those approaches. How it works is explained in the box (left). Under the standard test conditions illustrated, supply air at the outlet is delivered to the house at 54 degrees F and 100 percent humidity. When its temperature is raised to 77 degrees in the house, the relative humidity drops to around 60 percent.

The current prototype is a 2.1-ton (25,200-Btu/h) unit. To avoid corrosion, it is made entirely of plastics except for the heat-transfer partition, which is a plastic-coated metal. Albers says that it shows no measurable deterioration in performance after running 900 hours in the Tempe lab.

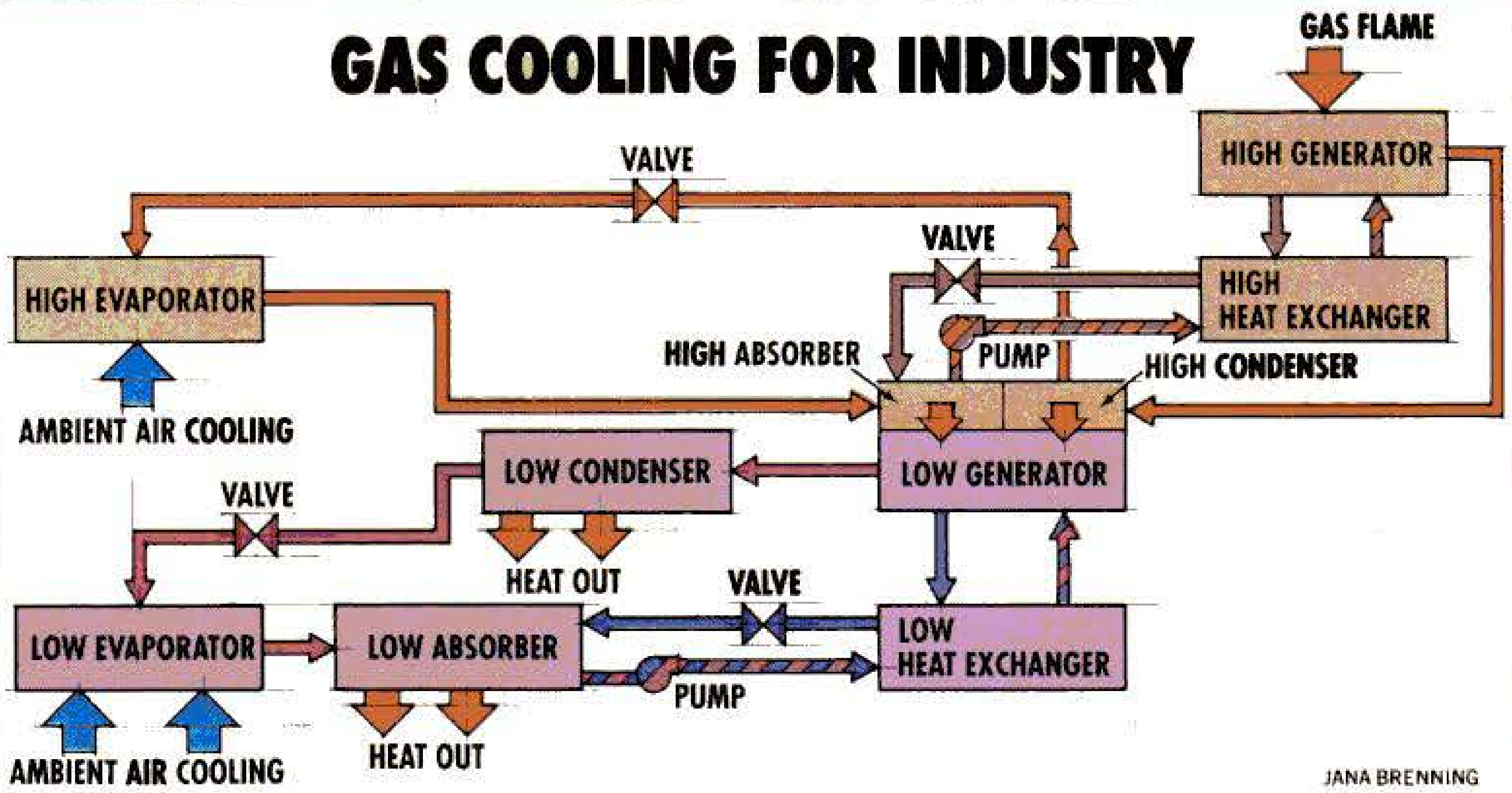
The company also has simulated more-humid climates for test purposes. The most difficult conditions they've simulated: 86 degrees F and 80 percent relative humidity. "Humidity is more of a problem for this machine than heat," Albers says.

In a hot, dry climate the Albers air conditioner uses about 20 percent less energy than an air conditioner with a Seasonal Energy Efficiency Ratio of 10, company tests show. Electricity is needed only to run two fans and 40 tiny pumps (linked so that two motors power all).

Cost savings could be much greater. In the prototype, natural gas fires the boiler that reconcentrates the lithium bromide solution. Gas is a cheaper energy source than electricity. "This means about a fifty percent cost savings in our area," Albers reports.

Albers and Beckman tout their machine's environmental advantage, but insist that it can compete with conventional air conditioners on economics alone. Purchase price, they say, will be no more: perhaps $2,000 for a central unit big enough to cool a 1,500-square-foot house in Phoenix. If that proves to be true, and the energy saving is anywhere near the 50 percent claimed, they may be right.
—*V. Elaine Gilmore*

GAS COOLING FOR INDUSTRY



JANA BRENNING

Gas-fired absorbtion air conditioners, which use no ozone-depleting chlorofluorocarbons, have existed for decades. But until now they haven't been efficient enough to compete with methods used today: Robert De Vault, an Oak Ridge National Laboratory researcher, has invented a gas A/C that is 50 percent more efficient than today's best gas absorbtion A/Cs. The Trane Co. is developing commercial units rated at 150 tons and greater.

In theory, a single-effect A/C uses one unit of gas-energy input to produce one unit of cooling, for a coefficient of performance of 1.0. A double-effect generates two units of cooling per unit of energy (COP of 2.0). But De Vault's system, the triple-effect, will have a COP of 3.0. (Because reality is never as neat as theory, production single-effects actually have a COP of 0.5 to 0.6; double-effects, 1.0 to 1.2; and triple-effects, 1.5 to 1.7.)

"The difference between single-effects and the triple-effect is an added single-effect loop," says De Vault. Half of De Vault's air conditioner is essentially a conventional single-effect loop. It uses water as the refrigerant and a lithium bromide salt solution, which has a high affinity for water, as the absorbent. "The second loop works like a single-effect, but at higher temperatures—up to 450 degrees [F]," says De Vault. The "high" loop uses water as the refrigerant, with Trane's proprietary salt mixture as the absorbent.

Combining the loops gives the air conditioner its efficiency. "Instead of rejecting it into the air, as in other systems, waste heat from the high loop is used to run the low loop," says De Vault. It all starts at the high generator (see illustration), where salt water is boiled. The resulting water vapor goes to the high condenser, where it gives up heat and becomes liquid. This heat is transferred to the low generator, a heat exchanger, and helps run the low loop. The water then evaporates in the high evaporator to cool building air.

Not all of the solution is vaporized at the high generator. The remaining more-concentrated hot salt water travels to the high heat exchanger and dumps some heat to fluid returning to the high generator. The solution continues to the high absorber, where the salt in it pulls in water vapor returning from the high evaporator. Heat produced by this chemical mixing is also dumped at the low generator to run the low loop. A pump brings the solution back through the high heat exchanger to the high generator, completing the cycle. Operating identically to the high loop, the low loop provides more building cooling at the low evaporator. When the A/C finally dumps the remaining heat, it has used most of the original energy from the gas flame. The air conditioners may be available in four years.—*Mariette DiChristina*

THE AUTOMOTIVE SOLUTION

Winter is in its final days, islands of snow still dot the landscape, yet the temperature is a blazing 100 degrees F and the humidity a sticky 40 percent. Far from being caught in the early throes of a global warming crisis, I'm in a General Motors wind tunnel with Kurt Hollasch, director of engineering at GM's Harrison Radiator Division in Lockport, N.Y. Next to us is a white 1992 Buick Le Sabre undergoing testing of an experimental air conditioner that uses an ozone-friendly refrigerant. A 50-mph wind rushes by, making our ties flap in the breeze, as Hollasch shouts over the din: "It's instant August. We've recreated a hot, humid day, perfect for testing automotive air conditioning." The simulated summer is effective—it's hot and muggy. But inside the sedan it is a cool and comfortable 70 degrees.

The Le Sabre is not in its final mechanical configuration and is still more than a year away from a Buick showroom. It is fitted with one of the first of an expected new generation of advanced alternate air conditioners that uses HFC-134a (tetrafluoroethane) as a refrigerant. From Detroit to Stuttgart, West Germany, to Tokyo, the heat is on the world's auto makers to develop car cooling systems that not only protect the ozone layer, but don't derail current styling trends or the drive for better fuel economy.

Car air conditioner refrigerants are a tempting target for regulators: By the EPA's estimate, automotive sources contribute a significant amount of the chlorofluorocarbons released in the United States—the single largest contributor to ozone depletion. All told, 107.5 million pounds of CFC-12 were used in 1989 cars. Eventually, all of it is expected to leak out and zap stratospheric ozone. Vermont has passed a law prohibiting the sale of 1993 model-year cars equipped with CFC-12-based air conditioners. Auto makers, like GM, say this action may force them to drop air conditioning—ordered by between 60 and 90 percent of buyers—on some models in Vermont until a coast-to-coast introduction of the alternate equipment. Others are looking at Vermont as a large-scale test fleet to evaluate the first non-CFC-12 air conditioners on the road.

Scientists and engineers are pinning their hopes on HFC-134a as a replacement for CFC-12, though acceptance is far from universal. An early favorite, HCFC-22 would have required much higher operating pressures and can easily seep through conventional hoses and seals.

Tony Mash, commercial director for ICI General Products, a major supplier of refrigerants to the automotive industry, describes HFC-134a as "a molecule made up of carbon, hydrogen, and fluorine that has no chlorine. It has an ozone-depletion potential of zero, which is exactly what the world is looking for."

The sudden interest in HFC-134a might seem like a flashback to Hollasch. He helped build and test some of the auto industry's first alternate air conditioners in the mid-1970s. He was fresh out of engineering school and the aerosol use of CFCs had just been banned. It seemed possible that CFCs used to cool cars could go the same way. The experiments 15 years ago revealed that HFC-134a has different thermodynamic properties and would require new or redesigned components that could lead to lower efficiency and the possibility of a slight fuel-economy penalty.

The key to vapor compression cooling efficiency is the ability of the working fluid to cross the boundary from liquid to vapor repeatedly. In this phase transition, heat is the currency for temperature exchange. Boiling the liquid refrigerant in an evaporator yields cooling power for the car's interior, while compressing and condensing the vapor back to a liquid requires rejecting heat through a condenser. In essence, the air conditioner pulls heat out of the car and sends it into an already warm world, where it will hardly be noticed.

An analysis of the theoretical performance of automotive air conditioning by Du Pont scientists shows that, all things being equal, an HFC-134a-based cooling loop would require six percent more energy than the same unit operating on CFC-12. For equal cooling, this deficit would have to be made up by the car's engine, leading to less available power, lower fuel economy, or both. But all things are not always equal, and the change to HFC-134a can be seen as an opportunity for innovation. Says ICI's Mash, "We have to accept that it is the refrigerant for the future and then simply design the air conditioning system around it."

The major changes expected are:

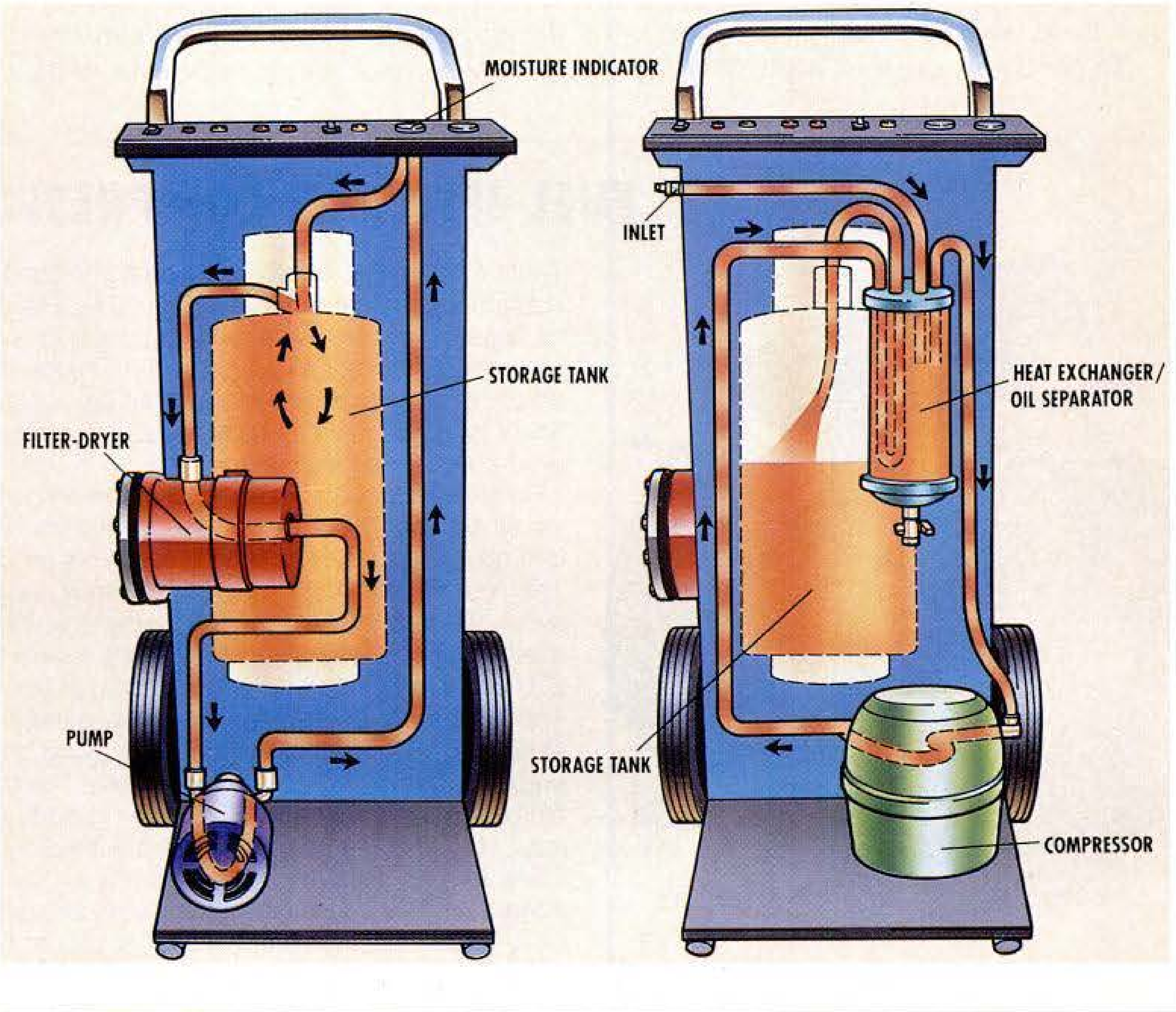
- Compressors will have to operate

RECLAIMING REFRIGERANTS

"In a manner of speaking, the ozone hole is the result of waste," says Philip Meredith, director of Freon products research and development at Du Pont. Industry practices until recently encouraged the squandering of CFC-12. One prime example was the venting of refrigerant and the use of it for leak testing. The new attitude emphasizes the frugal use of CFC-12, as if it were a high-priced specialty chemical. Over the next decade, CFC-12 will become just that: scarce and expensive as production slows and the $1.37 per pound tax takes effect, making reclaiming and reusing refrigerants economically and environmentally attractive.

The Kent-Moore ACR3 recycling system uses two loops to recover and clean the refrigerant. In the recovery mode (far right), the car's refrigerant flows through a heat exchanger/oil separator to remove waste oil and reliquefy the product. In the cleaning mode (right), a magnetically coupled pump routes the refrigerant from the bottom of the storage tank to the filter/dryer. When the refrigerant is ready for reuse, the moisture indicator changes from yellow to green.

Chlorofluorocarbon suppliers say CFC-12 may reach $4 per pound by the year 2000. By Kent-Moore's estimate, the typical shop can save $6,000 a year by recycling refrigerant and keep more than 5,200 pounds of CFC-12 out of the atmosphere.—*B. N.*



at about 10 percent higher pressure, requiring a sturdier structure, tighter internal tolerances, and stouter seals.

- HFC-134a seeps through rubber hoses more easily than CFC-12. The solution could be a hose lined with impermeable nylon.
- HFC-134a is more prone to moisture contamination, so a more effective desiccant will be required.
- Mineral-oil lubricants are not soluble in HFC-134a. They will probably be replaced by a synthetic polyalkaleneglycol oil to ensure against premature compressor failure.

But the air conditioner's condenser will undergo the most profound changes. Its ability to cool and liquefy refrigerant likely will determine success or failure. Refki El-Bourini of Calsonic's Technical Center in Phoenix says that based on a sophisticated computer modeling of thermodynamic performance, "a system built around HFC-134a will be limited by its ability to condense refrigerant. With higher condensing capacity, you can equal or beat CFC-12."

Improving condensation implies either larger or more-efficient heat exchangers, or more airflow through the engine compartment to carry off heat. However, each of these methods could force a reappraisal of the cab-forward styling trend that emphasizes a short, low hood with minimal grille area.

To continue present styling trends, the Calsonic answer to the increased condensing requirements is to use an innovative parallel-flow condenser, which its maker, Modine of Racine, Wis., calls multiflow. Looking at parallel-flow and traditional serpentine condensers side by side, the differences are immediately apparent. The parallel-flow unit, constructed of many small tubes with a header at each end, is smaller in all dimensions and weighs half as much. It also has 13 percent less frontal area. A serpentine condenser routes refrigerant through the convoluted zigzag of a long pipe with many right-angle bends. The result is 30 percent more heat exchange in a parallel-flow unit compared with a serpentine condenser. The smaller size also allows designers to use 20 percent less refrigerant and get the same cooling power compared with the production CFC-12 system.

Standardized road tests of the Calsonic prototype A/C mounted on a 1988 Nissan Stanza show that the experimental unit's performance was equal to or better than the car's standard CFC-12 air conditioner under all test conditions. El-Bourini says that his supervisor drove the test car last summer and complained that the alternate air conditioner worked so well in Phoenix's 100-degree weather that he had to hold it to the lowest setting to keep from shivering.

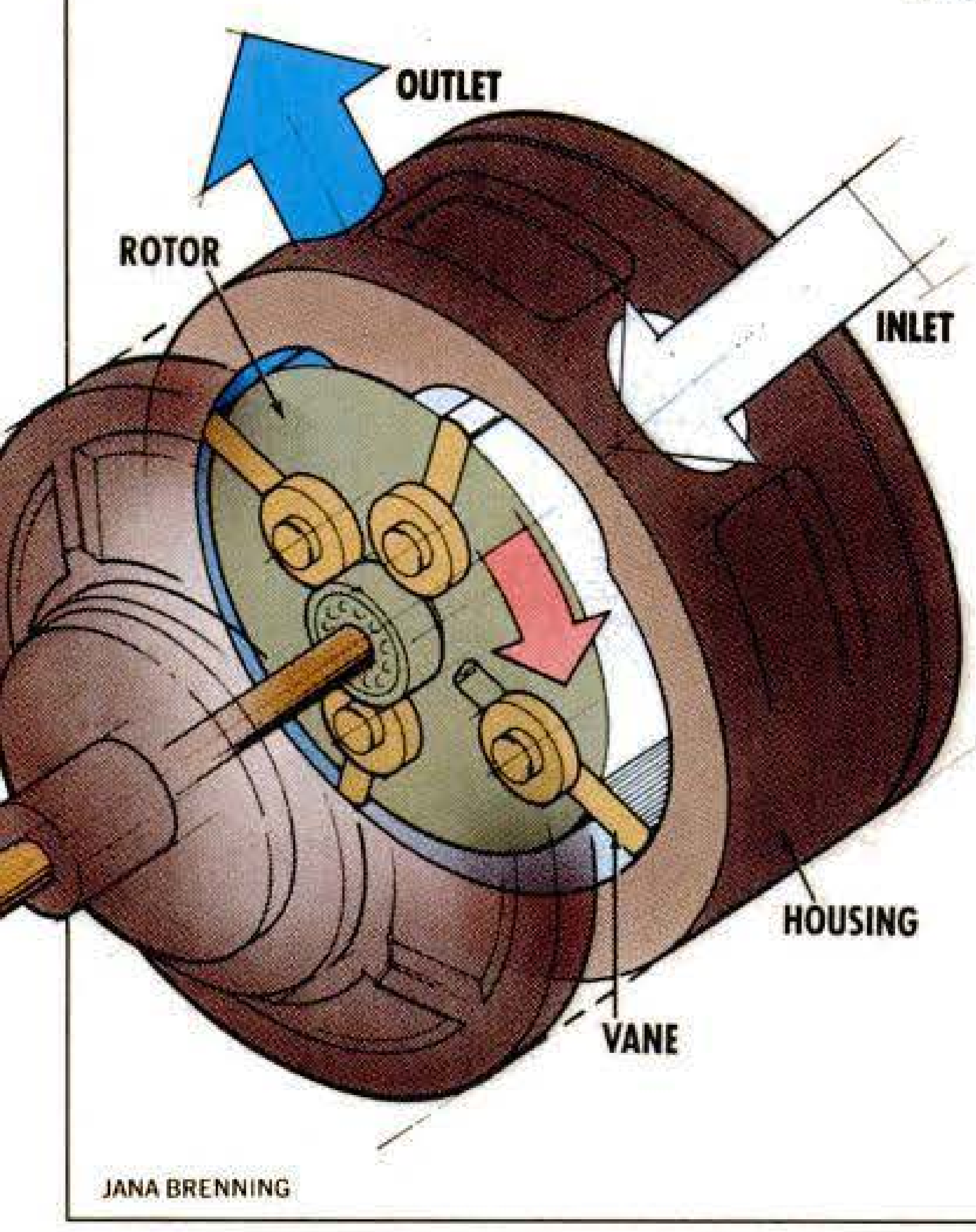
Before any car leaves the laboratory for road testing, the prototype air conditioner has already gone through extensive bench-top and wind-tunnel testing. Hollasch calls this phase of development "an artificially contrived situation to simulate aspects of the real world." He says, "In the lab you can test under the worst possible conditions and beyond." In the wind tunnel a full system can be evaluated for the hottest, most uncomfortable day, even if a blizzard is raging outside.

Then it's time to hit the road. Hollasch says there are "hundreds of prototypes on the road right now, and we're putting out more every day." In a cooperative venture, the Niagara County Sheriff's Department has let Hollasch's engineers retrofit its squad cars with prototype HFC-134a air conditioners. The final tests have not been completed, but Harrison's chief engineer says he's optimistic that GM's planned phased introduction of alternate air conditioners for the 1993 model year will go smoothly. First-year volume will probably encompass several assembly plants, and volume could approach 500,000 cars.

Despite early warnings that the change to HFC-134a would be accompanied by a 10 percent loss of fuel economy, El-Bourini, Hollasch, and others I spoke with report that initial tests with prototypes show no loss of efficiency. In an era when the minimum corporate average fuel economy (CAFE) could be raised from 27.5 to 40 mpg, engineers and designers alike must squeeze the most out of every drop of gasoline.

To improve cooling without a fuel penalty, engineers are also looking at using passive technologies to give the air conditioner a helping hand. This approach includes solar-powered fans to circulate air while the car sits in the sun, and even glass like the PPG Industries' Sungate windshield ["Big is Back," Oct. '89] used on the GM

FUEL-EFFICIENT COMPRESSOR



JANA BRENNING

While most of the automotive industry is concentrating on modifying existing compressors to operate with refrigerants like HFC-134a, Rovac, a small Massachusetts engineering company, is taking the alternate route of basing its system on a novel rotary vane compressor. If the compressor looks familiar, it should. The device first appeared in these pages as a prototype automotive air conditioner that used air as the working fluid ["Rovac," Feb. '75]. Rovac engineers long ago gave up using air as the refrigerant, but still hope to produce an ozone-friendly air-conditioning system by 1992.

Rovac's Raymond Shea Jr. says the company has not decided which of three refrigerants would be used. "But it will have near-zero ozone depletion and global warming potentials, and operate at about half the pressure of HFC-134a, so efficiency will be higher," says Shea. The compressor works by gradually squeezing the refrigerant into an ever-smaller space between the rotor and the inner housing wall (see illustration). As the distance decreases, pressure increases. Vaporized refrigerant enters the inlet at about 35 psi and is swept through 270 degrees by one of the four vanes; at the outlet its pressure has reached 125 to 150 psi. The refrigerant is then liquefied in a parallel-flow condenser and boiled in a conventional evaporator. The gap between the housing and the vanes is the critical element in the compressor's design, which Shea says "is a few thousandths of an inch" and still needs to be optimized for durability and efficiency. He adds that the durability goal is an estimated life of at least 10,000 hours, which is equivalent to 250,000 miles at an average speed of 25 mph.

Wind-tunnel tests show the system will be about five percent more efficient than a HFC-134a-based air conditioner with a conventional compressor, says Shea. In addition, the company has tested four prototypes in a pair of Dodge Shadow coupes that perform as well as standard CFC-12 units, but with a slight improvement in fuel economy.—*B. N.*

APV minivan. Between its two sheets of glass is a multilayer metallic coating that reflects or absorbs 60 percent of the sun's infrared radiation so that the minivan can keep cool. Further in the future, we may see glass that automatically darkens in bright sunlight both to reduce the load on the air conditioner and keep a constant light level on the driver's eyes.

These are but the first tentative steps on the journey to doing away with CFCs in automotive air conditioners. It is expected that as experience and familiarity with the new refrigerant and equipment grow, so will ideas on how to optimize and refine the equipment. Hollasch describes present systems as fully developed: "There are fifty years of technological development built up in CFCs and automotive air conditioning. We're trying to replicate that sophistication in a few years."—*Brian Nadel*

REFRIGERATORS THAT STAY COOL WITHOUT CFCs

They're not much to look at. Maybe that's why refrigerators, ubiquitous and seemingly innocuous, haven't attracted much attention during the last 30 years. But the next few years will be different. The 20,000 refrigerators produced in the United States daily will have to undergo radical transformations. Manufacturers will be replacing current ozone-zapping refrigerants with alternative chemicals. By the mid-1990s, fundamental changes in refrigerator designs and materials will come.

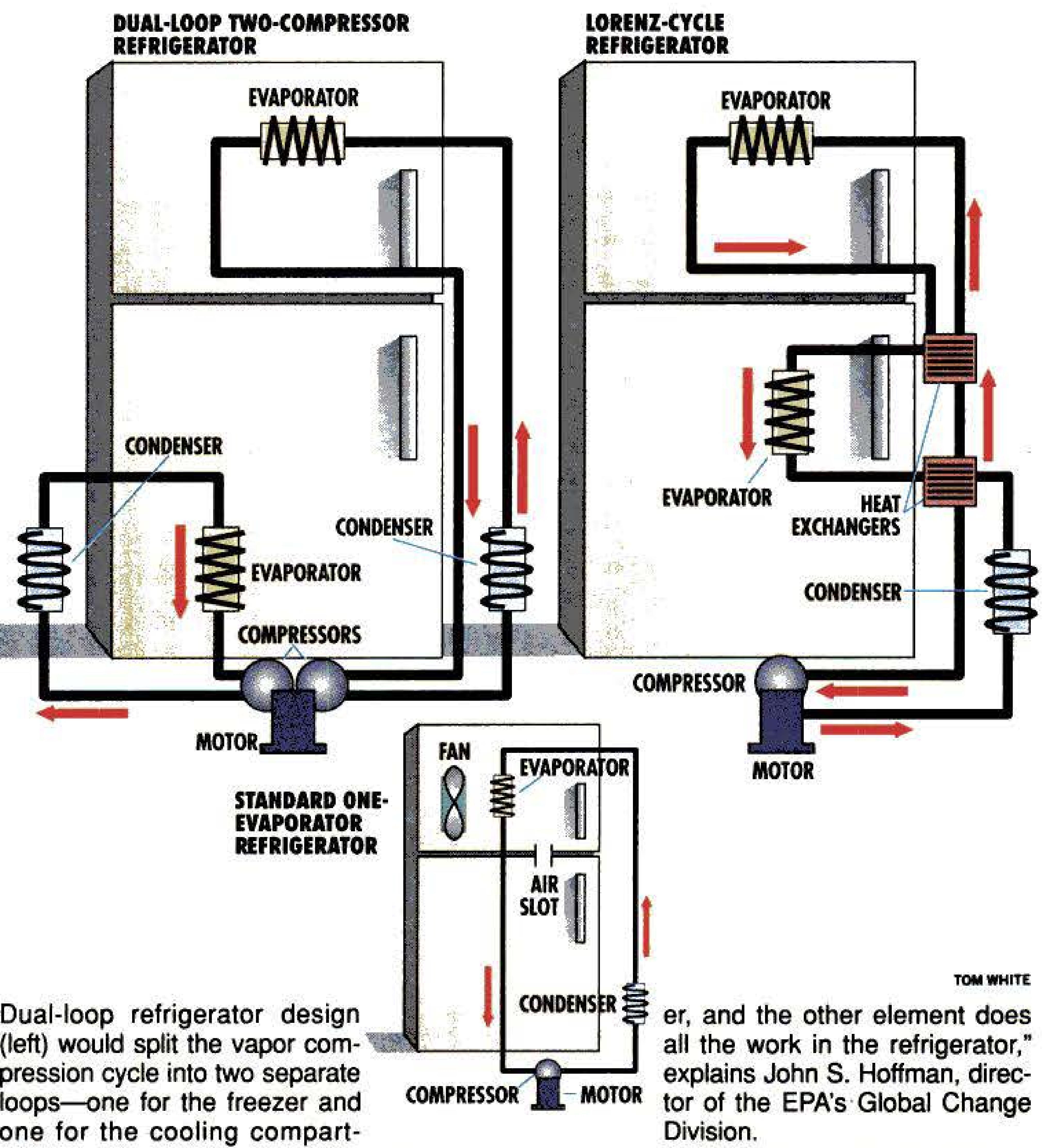
In a $700 refrigerator, chlorofluorocarbons weigh only a few pounds and cost about $10. Yet CFCs are essential components. CFC-12 is the working fluid in a conventional refrigerator's vapor compression cycle, and CFC-11 is a blowing agent used to produce the foam insulation for the refrigerator's shell. Both chemicals destroy ozone. About five percent of all CFCs produced are used in domestic refrigerators and freezers.

Refrigerators also consume 20 percent of household electricity, much of which is produced by burning fossil fuels that release carbon dioxide and contribute to global warming.

Several states and the federal government have set stringent minimum-energy-efficiency standards that will require refrigerators to use 25 percent less electricity by 1993. Until recently, refrigerator manufacturers have been able to boost efficiency by using more CFCs. Now they must develop alternatives that are not only harmless to the environment but also meet energy-efficiency goals. This is an enormous challenge for companies that ordinarily devote their research to features such as ice makers and defrosters.

[*Continued on page 90*]

TWO-CYCLE REFRIGERATORS

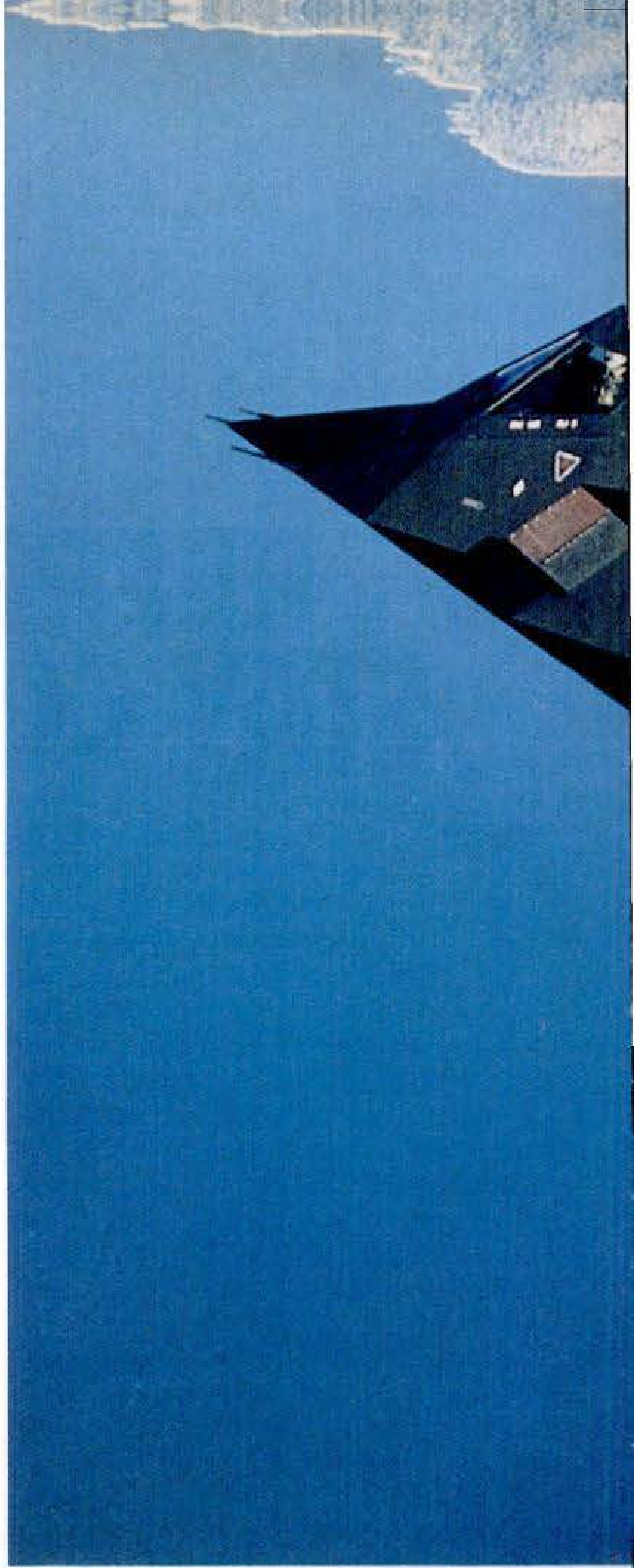


Dual-loop refrigerator design (left) would split the vapor compression cycle into two separate loops—one for the freezer and one for the cooling compartment—each with its own evaporator. Some designs call for two condensers and compressors as well.

Another type of two-evaporator system (right) would use a non-azeotropic refrigerant mixture—a blend of chemicals that normally evaporate at different temperatures but in combination evaporate over a range of temperatures. "One element of the mixture basically does all the work in the freezer, and the other element does all the work in the refrigerator," explains John S. Hoffman, director of the EPA's Global Change Division.

Named the Lorenz cycle, after the German scientist who invented it 15 years ago, this system is 20 to 25 percent more efficient than a standard refrigerator, which wastes energy by chilling air in the freezer before blowing it into the cooling compartment. And unlike a conventional refrigerator, the Lorenz cycle doesn't dehumidify the cooling compartment. "It will be much friendlier to your vegetables," says Hoffman.—*D.S.*

SPOTLIGHT ON THE STEALTH FIGHTER



No longer a phantom, the F-117A has emerged from the shroud of Air Force secrecy. A POPULAR SCIENCE correspondent was on hand to get a close-up look.

By J. T. JOHNSON

It was 9 a.m. on a Saturday, and 2,000 people were scanning the overcast northern sky just above the mountain range 20 miles beyond the runways of Nellis Air Force Base in Las Vegas.

At 9:05 a.m. two specks popped into view. Specks that soon revealed themselves to be so angular that they challenged all notions of what a modern fighter plane should look like. For 10 years, the existence of the F-117A was as ghostly as the plane's image on a radar screen. Now, for the first time, the Air Force has taken the wraps off its top secret stealth fighter.

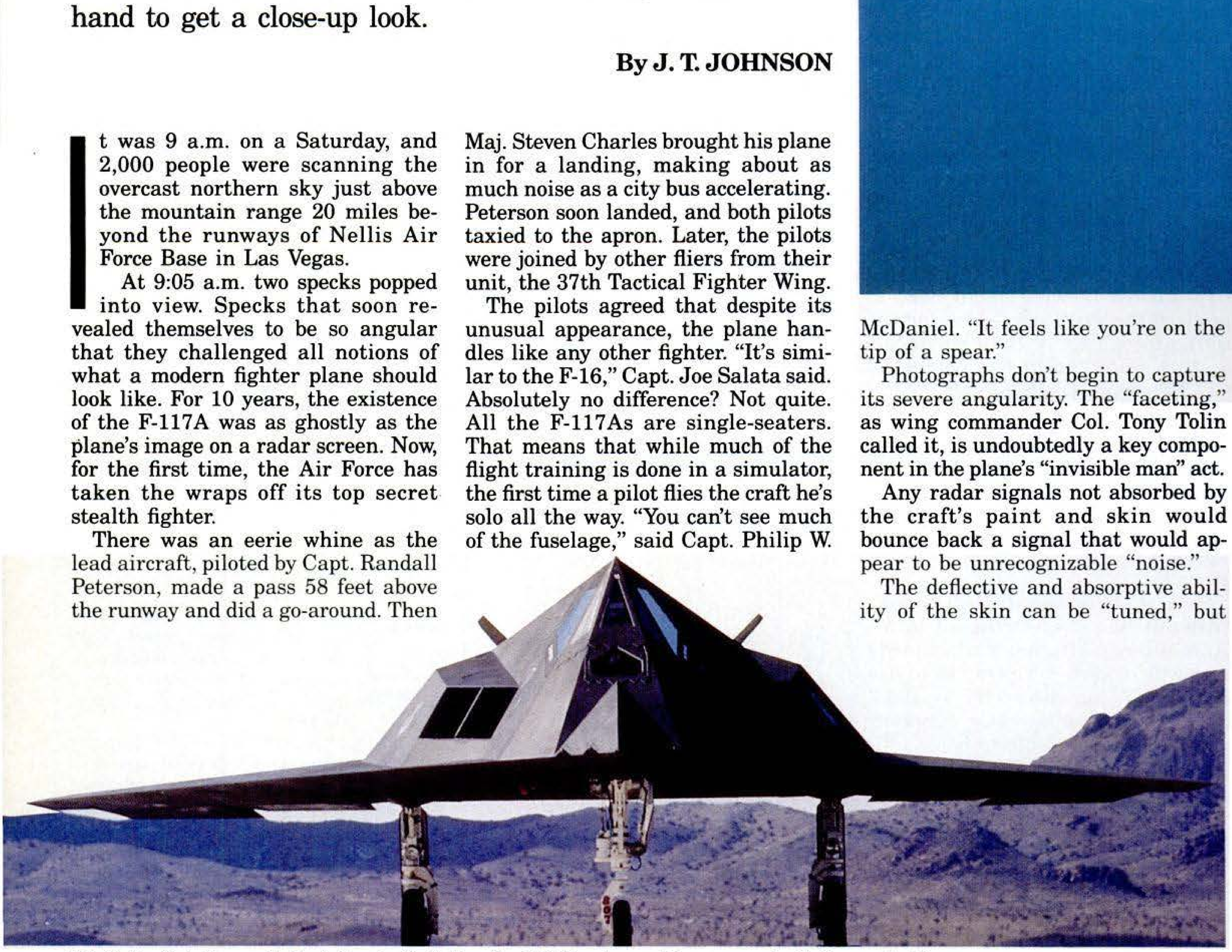
There was an eerie whine as the lead aircraft, piloted by Capt. Randall Peterson, made a pass 58 feet above the runway and did a go-around. Then Maj. Steven Charles brought his plane in for a landing, making about as much noise as a city bus accelerating. Peterson soon landed, and both pilots taxied to the apron. Later, the pilots were joined by other fliers from their unit, the 37th Tactical Fighter Wing.

The pilots agreed that despite its unusual appearance, the plane handles like any other fighter. "It's similar to the F-16," Capt. Joe Salata said. Absolutely no difference? Not quite. All the F-117As are single-seaters. That means that while much of the flight training is done in a simulator, the first time a pilot flies the craft he's solo all the way. "You can't see much of the fuselage," said Capt. Philip W. McDaniel. "It feels like you're on the tip of a spear."

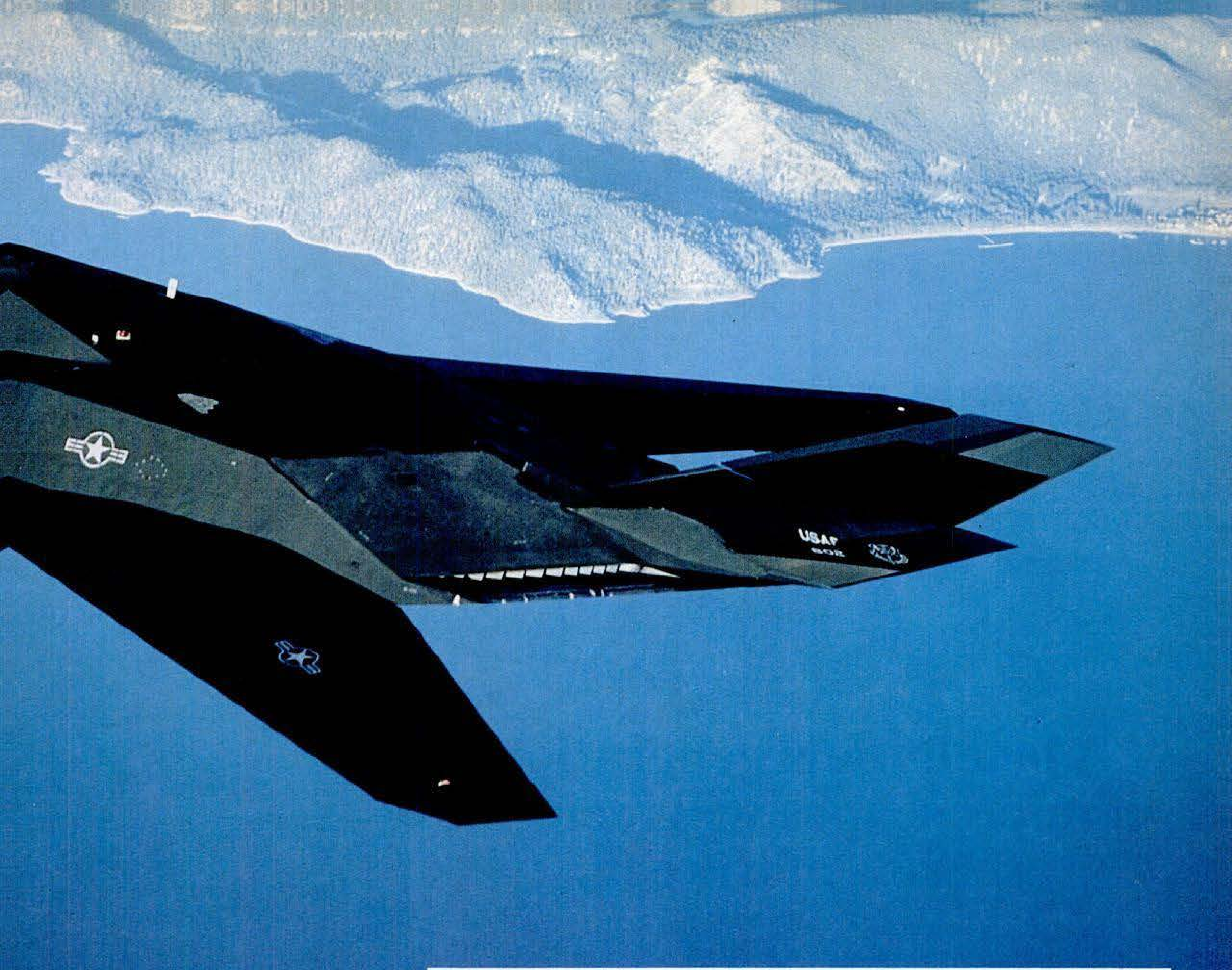
Photographs don't begin to capture its severe angularity. The "faceting," as wing commander Col. Tony Tolin called it, is undoubtedly a key component in the plane's "invisible man" act.

Any radar signals not absorbed by the craft's paint and skin would bounce back a signal that would appear to be unrecognizable "noise."

The deflective and absorptive ability of the skin can be "tuned," but



This is the first close-up look at the stealth fighter, the F-117A, whose existence was ghostly for nearly 10 years.



In-flight photos of the F-117A reveal faceting details that seem to defy the conventions of aeronautical design. The refueling shot (right) shows the relative size of the fighter and the tanker, a wide-body DC-10.

whether this refers to the recipe used to produce the matte-finish black material, or whether the facet angles can be varied on the ground or in flight, the Air Force won't say. The leading edge of the wings—like every angle on the craft—tapers to a knife edge instead of the rounded form usually thought necessary to provide lift to an airplane.

A sawtooth treatment on the back edge of the cockpit side windows and on the bottom of the windshield also is thought to dissipate radar signals.

The intake ports for the F-117A's two GE-F404 engines are covered with a radar-absorptive composite grid that blends into the lines of the wing/fuselage. Exhaust from the non-afterburner engines is deflected upward through a series of ports stretching along both sides of the rear fuselage on the $106.2 million plane. Both intake and exhaust ports are positioned to eliminate or minimize hot spots picked up by infrared detectors.

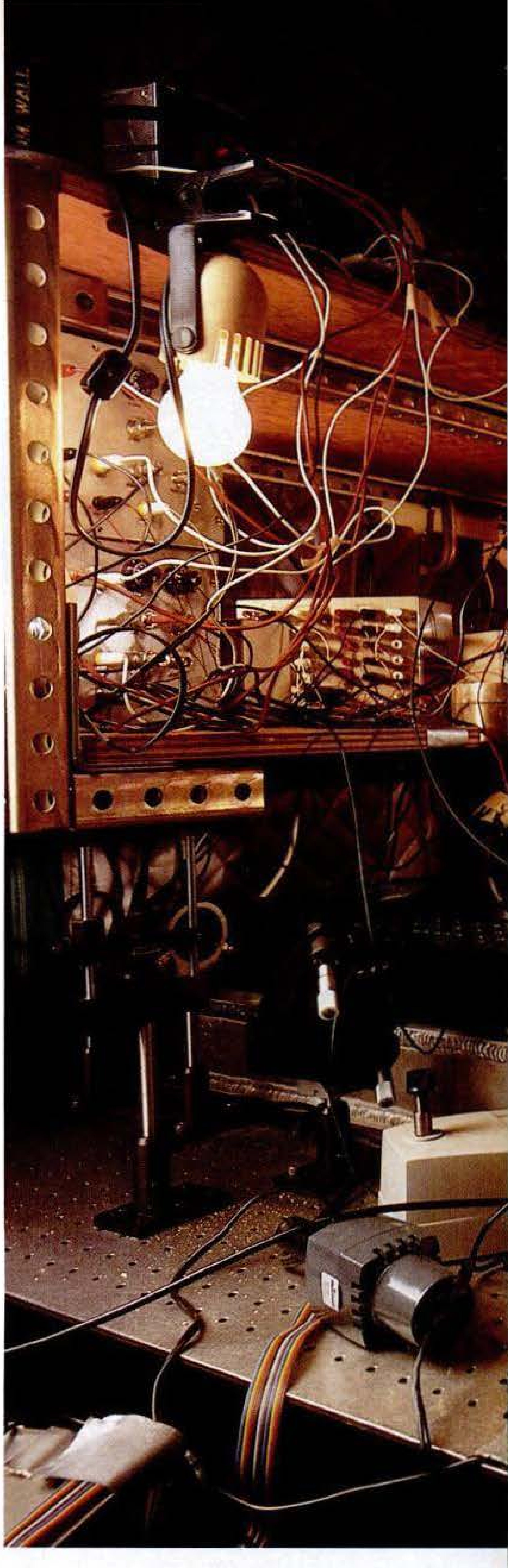
The resulting stealthiness was the reason two F-117As were used to drop two 2,000-pound bombs with "pinpoint accuracy," during the October invasion of Panama. In fact, one of the bombs fell "way off target," and by April, Defense Secretary Dick Cheney was demanding the Air Force explain the earlier claims.

Also in mid-April, with Congress debating the defense budget, specifically that of the F-117A's cousin, the B-2 stealth bomber, Air Force commanders hoped a demonstration of the F-117A would help their cause. But a week after the fighter's showing, Cheney asked Congress to fund 75 B-2s, not the 132 originally sought.

SUPER SCOPES

A bright new generation of microscopes will focus on secrets of the cell.

By ARTHUR FISHER



They said it couldn't be done. The laws of physics just wouldn't permit it. You absolutely, positively could not build a light microscope that could see things smaller than, say, $^{1}/_{125,000}$ inch in size. That meant light microscopes could not visualize some viruses, much less molecules.

But now a new generation of microscopes is beginning to appear in laboratories around the world. They use light to image their subjects, yet these "superscopes" have seen objects 10 times smaller than once thought possible. And their inventors believe that achievement can be improved many-fold.

The benefits anticipated from these new instruments range from studies of the surfaces of living cells to the nondestructive inspection of ever-shrinking microelectronic devices. The light microscope I saw at Cornell University has been used to examine viruses and muscle cells, integrated circuit chips, and geological mineral specimens that could provide clues to oil-bearing deposits. It could even improve the detection of diseases by high-resolution imaging of tissues stained with diagnostic dyes.

The key to their once-impossible performance is that the new instruments use light, but do not use lenses. Instead, their geometry permits them to gather light just after it has passed through an extremely narrow aperture. Just how does this arrangement allow an apparent violation of the laws of optics? Professor Michael Isaacson of Cornell explained the basic principles as we sat in his laboratory. The instrument, which has been called variously a superoptical microscope and (more properly) a near-field scanning optical microscope, or NSOM, looked much like the seemingly chaotic jumble of electronics and stainless-steel plumbing that can be found in most modern physics labs.

Isaacson has been teaching a course at Cornell in something he calls microcharacterization—the ability to describe things that are smaller than $^{1}/_{10,000}$ centimeter on a side. "It's an interdisciplinary thing," he says, "that involves physics, applied physics, chemistry, electrical engineering, mechanical engineering, materials science...."

And that pursuit naturally involves the instruments that can image microscale objects. "My main interest is

Cornell University's Michael Isaacson playfully peers through a magnifier alongside the near-field scanning optical microscope, whose acronym, NSOM, appears in the scope's image (inset). The aluminum forming the letters is only 250 angstroms thick.

JOHN B. CARNETT

essentially looking into the physics of building novel microscopes...I'm a gadgeteer, for lack of a better word... In my course, we try to make comparisons of different instruments. A lot of my students will be going into industry and will be responsible for deciding which half-million and million-dollar instruments they should order to solve a particular problem."

Perhaps the most important basis for comparison of the many kinds of microscopes now available is resolution—the ability to distinguish one microscopic object from another. (If resolving power is low, no amount of increased magnification will help; that's why the high magnifications of some cheap children's microscopes—500x to 1,000x, for example—are misleading. At those magnifications, the instrument is simply blowing up a blur.)

The resolving power of any instrument is limited by the wavelength of the energy it uses to image a small object. For a conventional light microscope—one using lenses—that limit is about half the wavelength of visible light, which ranges from about 400 nanometers (billionths of a meter) for violet light to 700 nanometers for red light. "That translates, Isaacson says, "to the order of a half a micron or so." (Physicists use a somewhat confusing medley of units in measuring light and the size of microscopic objects. A nanometer is one-billionth of a meter, about 400 millionths of an inch; a micron is one-millionth of a meter. An angstrom—symbol A, named after a 19th century Swedish physicist—is one 10-billionth of a meter, or one-tenth of a nanometer. So the wavelength of violet light is also written 4,000 A. All clear?)

To achieve a higher resolution, an instrument must use shorter wavelengths of energy—the path that led to electron microscopes in all their varieties and most recently to the scanning tunneling microscope and the atomic force microscope ["Seeing Atoms," April '89].

"As my students and I compared various instruments," Isaacson says, "we saw that the instruments normally used for getting high resolution were also the ones that necessarily damaged the objects you were looking at. But if you look at instruments that are completely nondestructive, like the normal light microscope, you're limited by the fact that they have very low resolution. To get better resolution, you go to lower wavelengths: You go from photons of light to electrons to ions—the key is reducing the wavelength of the particle." The catch is a fundamental rule. If you reduce the wavelength, you increase the energy of the radiation. And the higher the energy, the more damaging it is. Also, some of these techniques mean having to place the specimen in a vacuum, which adds to the damage to biological subjects.

"Even when people use light nondestructively, if they want to get a little bit better resolution, they go to ultraviolet light. Short-wavelength UV, say down to 2,000 angstroms, is OK for some things, but it's destructive for biological specimens."

It would seem, then, that if the goal is to visualize biological systems with the least injury to their structure

—meaning without ionizing radiation and without having to operate in a vacuum—high spatial resolution and the ability to see superfine details of that structure must be sacrificed.

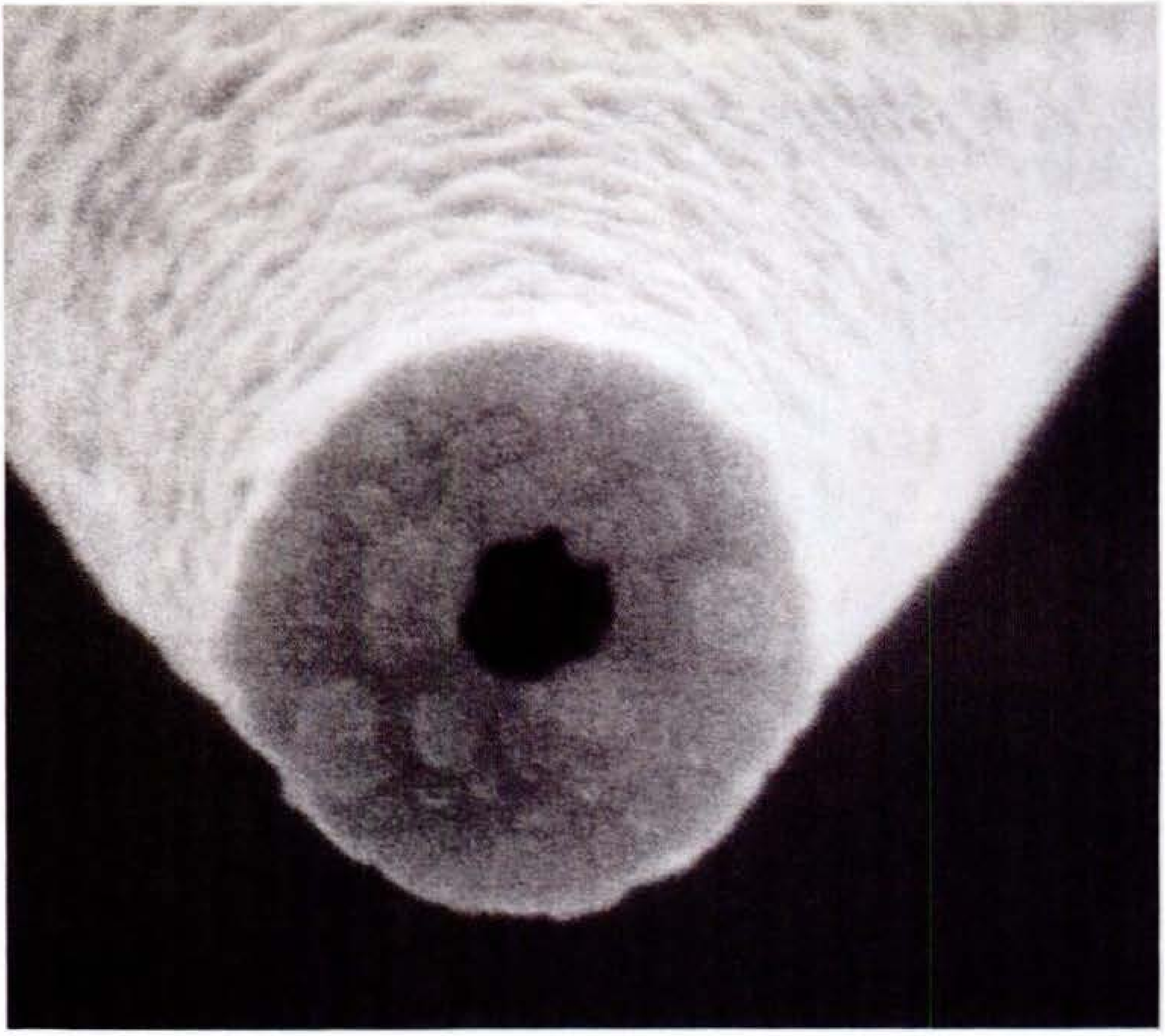
But there is a way around that obstacle. It has to do with the fact that it's actually the lens in an optical microscope that imposes the limit. The lens focuses light in a region relatively far from the object. By the time light has reached this region, called the far field, it has spread out, or diverged, from a narrow beam, and the laws governing the relation of object size and wavelength hold.

But suppose the light is made to pass through a tiny aperture, much smaller than the light's wavelength. And suppose that light is scanned very close to the aperture —much less than a wavelength away—in a region called the near field. Then the beam of light does not have a chance to diverge; in the language of physics, it is collimated to the diameter of the aperture itself. Because this collimation effect is independent of wavelength, the resolution limit characteristic of conventional microscopes with lenses does not apply.

Isaacson uses a simple analogy: "Let's look at a garden hose with a nozzle of a certain diameter. I shoot water through the hose. If I stand three feet away from the nozzle, I'm just sprayed all over. But if I get very close to the nozzle, I'm sprayed with a stream of water whose diameter is only as wide as the nozzle's aperture. The same thing happens with light. Very close to the hole, in the near field, the light beam is defined only by the size of the hole, not by the wavelength. So I get around the limit. I have a way of getting a beam of light that is much smaller than a wavelength.

"So instead of focusing light with a lens, I take the light, pass it through a very narrow aperture, and put my sample so close to that aperture that the light beam doesn't have a chance to spread out."

To generate a picture of the subject, which of course is far larger in extent than the ultra-narrow beam of light, the beam is scanned over the subject's surface and the light thus transmitted through the sample is collected by a microscope objective in the far field and fed to a photodetector. An image is built up a line at a time on a video monitor—the only thing Isaacson actually looks at. This raster pattern is the same as the one that produces an image on a TV screen. In some versions of the instrument, the subject is moved for scanning itself.



The business end of Cornell's near-field optical scanning microscope is a glass pipette drawn to a narrow tip with a tiny hole in the end, above. At other laboratories, the fluorescence of a tiny crystal of anthracene (glowing blue, right) is used to get more light through.

In practical terms, the dimensions involved are breathtakingly small. For optimum results with visible light of about 5,000-A wavelength, and an aperture of about 500 A, Isaacson and his colleagues must be able to position the sample within a couple of hundred A. Moreover, they must be able to control that position precisely, to 10 A or so (the average diameter of an atom is one to three A) and move the scanning stage in steps at least one-half smaller than the aperture.

Isaacson points out that Cornell's near-field microscope has been under development for about seven years. But the concept underlying near-field instruments was first advanced by physicist John O'Keefe in 1956. The validity of the technique was confirmed in 1972 by E. A. Ash and G. Nicholls using microwave frequencies. But incorporating the basic principle into an instrument using visible light had to wait more than a decade, says Isaacson, because techniques for micropositioning and aperture fabrication had to be improved by four or five orders of magnitude.

It's easy to bandy the phrase "a 50-nanometer aperture," but the true dimensions of the problem sink in when you realize that Isaacson is talking about making a hole that is about 1/1,000 the diameter of a human hair, and then finding a means to pass light through it.

The technique for making such holes, however, is similar to that used in making the micropipettes —which are called catch clamp pipettes—that biologists use to probe the interiors of cells, and it is almost brutally simple. A hollow glass capillary tube is heated in the middle until the glass softens, and is then pulled apart until the ends are drawn to an extremely fine diameter and the two pipettes so formed break apart.

"We developed our own little machine to do this and were going to patent it until we learned that biologists can buy an off-the-shelf machine for about a thousand dollars that does the same thing," says Isaacson. "You can taper the glass right down to the end, and draw it so you have a very long tip with a hole in the end. Then you evaporate aluminum so that you deposit a very thin metallic coating on the side of the tip and on the flat part of the end wall. That ensures that the light has nowhere to go except out the very narrow hole."

The light source is a light-transmitting fiber-optic strand placed inside the pipette.

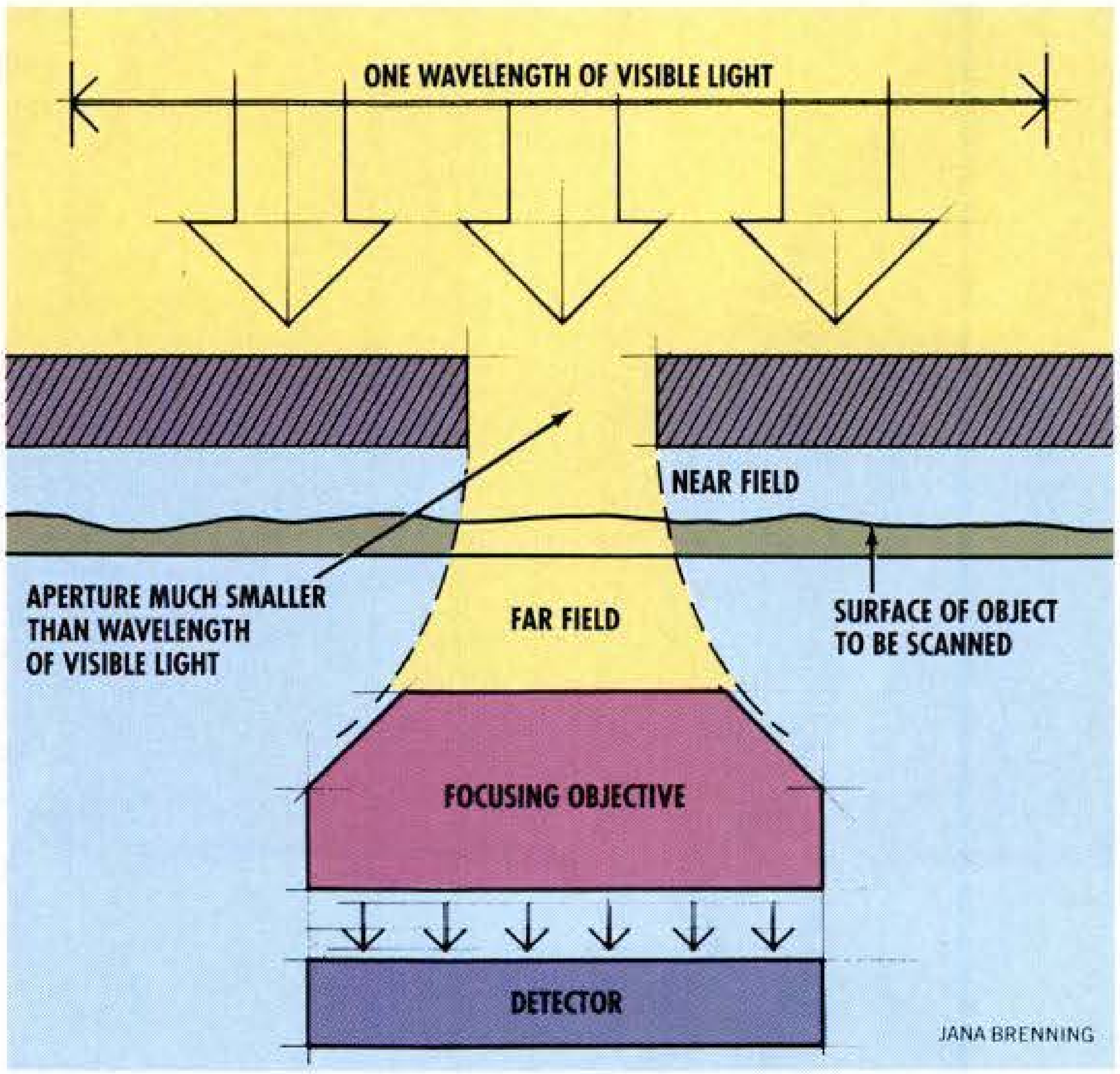
The pipettes I saw were slender, glistening tubes of glass with tips that seemed thinner than spider's silk. When I peered at the ends to see if I could make out the holes, Isaacson said, "You can't see them. They are much smaller than the wavelength of visible light, so you can't see them in visible light." The photo of a pipette tip showing the aperture that appears in these pages was made not with visible light, but with a scanning electron microscope.

The achievement of Cornell's near-field microscope so far is a resolution at least 10 times better than the limit for conventional optical microscopes.

"Right now," says Isaacson, "using light of 550 nanometers—that's greenish-yellow—we can get about forty-nanometers resolution. That's about one-twelfth of the wavelength. I think we can get down to one-twentieth, and maybe even to one-fiftieth of the wavelength. So we're not going to be able to see atoms, like an STM [scanning tunneling microscope]. But the thing is that it's an optical technique—using light. And light is the key.

"How far down can you go? One of the things that limits you is that the smaller the aperture, the less light goes through, because the wavelength of the light is so much larger than the opening. Maybe you get out only one ten-thousandth of the light you put into the tip. So eventually you reach a fundamental limit: The amount of light going through is so small that it becomes undetectable."

One effort to grapple with that limit is under way in laboratories at Hebrew University in Jerusalem with a team headed by physicist Aaron Lewis, and at the University of Michigan with professor of chemistry Raoul Kopelman. Their technique, Kopelman told me, relies on the production of entities called excitons, which exist and travel only within crystalline solids.


ONE WAVELENGTH OF VISIBLE LIGHT
NEAR FIELD
APERTURE MUCH SMALLER THAN WAVELENGTH OF VISIBLE LIGHT
FAR FIELD
SURFACE OF OBJECT TO BE SCANNED
FOCUSING OBJECTIVE
DETECTOR
JANA BRENNING

Near-field microscopy resolves objects 10 times smaller than do normal optical scopes. The trick is to pass light through an aperture smaller than the wavelength of visible light and then use it to image an object in the "near field"—before the light has a chance to diverge. Thus the effective wavelength is much smaller than the actual one.

"It's very tough to stuff light through a narrow opening," says Kopelman. "Photons don't want to get squeezed through. But if we repackage the light as excitons, there is no longer a problem about passing the bottleneck. Excitons are traveling packets of energy, but they transfer no mass and no charge. Unlike photons, they cannot travel in a vacuum. When a molecule or an atom in a crystal is bombarded with energy and becomes excited—that is, one of its electrons jumps to a higher energy state—the electron stays where it is with the molecule or atom. But when the electron drops back down to its original energy level, an exciton can hop over to the next molecule and transfer the energy."

One of the differences between the exciton and a photon is size. Because of the dual wave/particle nature of light, the size of a photon of light is comparable with the light's wavelength—about 400 nanometers for the shortest-wavelength visible light. But the size of an exciton is on the order of a molecule, perhaps a nanometer.

To take advantage of this property, Kopelman, Lewis, and their colleagues used an ingenious stratagem. They plugged the 50-nanometer hole of a glass pipette tip with a tiny crystal of anthracene grown there. Anthracene is an organic substance derived from coal tar, and it was chosen because it is known to fluoresce under the appropriate stimulation. When the experimenters beamed a ray of ultraviolet light from an argon-ion laser down the pipette, it set off a train of excitons inside the crystal. The excitons passed easily through the tip until they reached the boundary of the solid crystal.

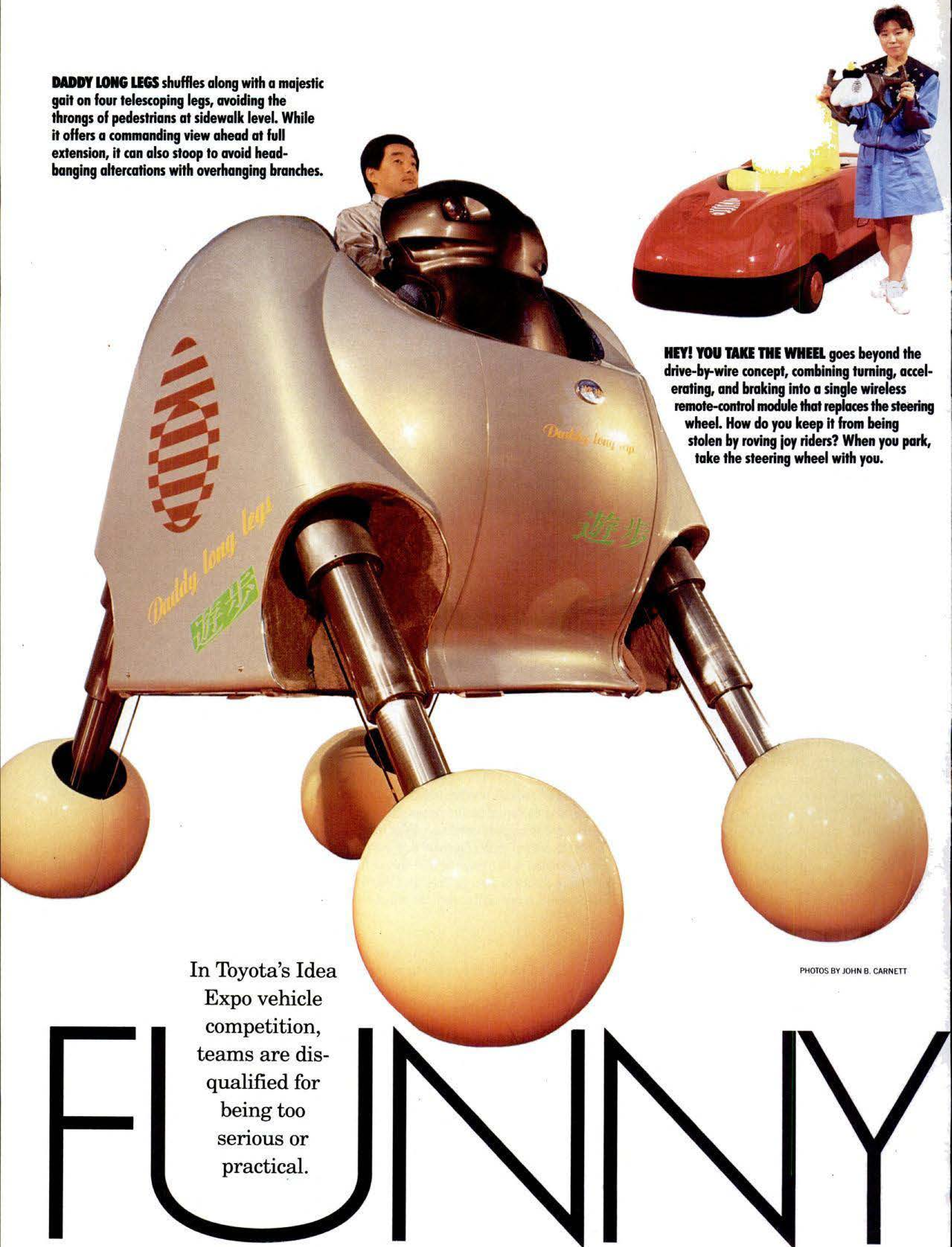
"Excitons always die," says Kopelman. "They have a lifetime of about five nanoseconds. And this crystal has an efficiency of one, which means that every exciton that dies becomes a photon. So we get the excitons through the hole, they turn into light, and the anthracene fluoresces." (The result can be seen here in the photo of the tip, with the crystal emitting blue light.)

The net effect, says Kopelman, is to be able to build a near-field microscope that is much brighter than was previously possible. Light intensity decreases exponentially with the decreasing diameter of the aperture when light is used. But the excitonic approach means that the light intensity should decrease only geometrically for the same aperture reduction. In preliminary experiments, the Michigan and Jerusalem researchers found that up to three times as much light emerged from the pipette tip with this method as from a hollow tip with the same size hole.

"I believe," Kopelman says, "that we have a technique that can eventually use visible light to image objects down to the size of molecules—on the order of ten angstroms."

Moreover, the availability of such minute yet relatively bright light sources opens the possibility of significant advances in integrated optics. Cheap, compact short-wavelength light sources could replace light-emitting diodes and diode lasers in optical computers, with considerable gains in size and efficiency.

DADDY LONG LEGS shuffles along with a majestic gait on four telescoping legs, avoiding the throngs of pedestrians at sidewalk level. While it offers a commanding view ahead at full extension, it can also stoop to avoid head-banging altercations with overhanging branches.

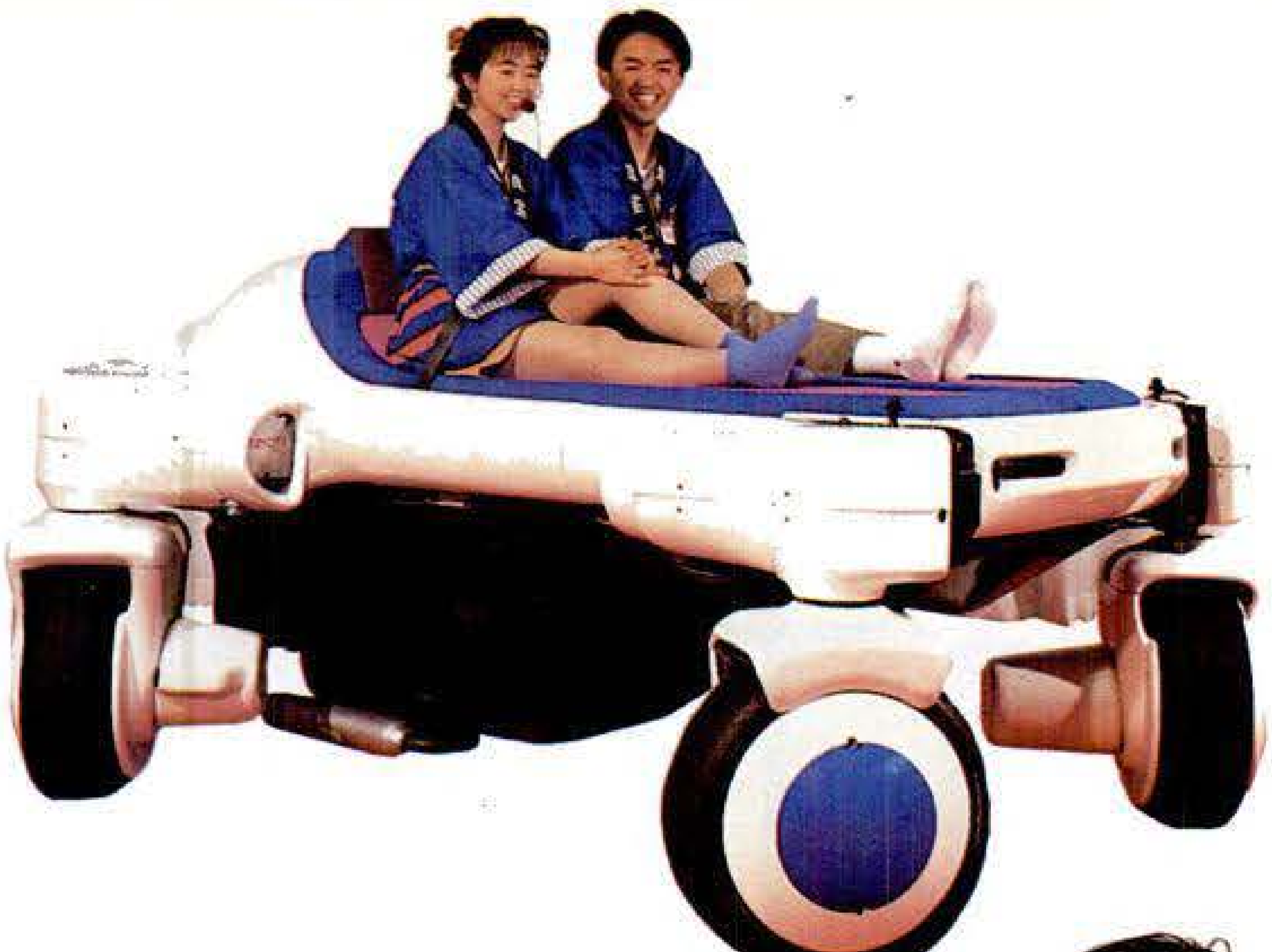


HEY! YOU TAKE THE WHEEL goes beyond the drive-by-wire concept, combining turning, accelerating, and braking into a single wireless remote-control module that replaces the steering wheel. How do you keep it from being stolen by roving joy riders? When you park, take the steering wheel with you.

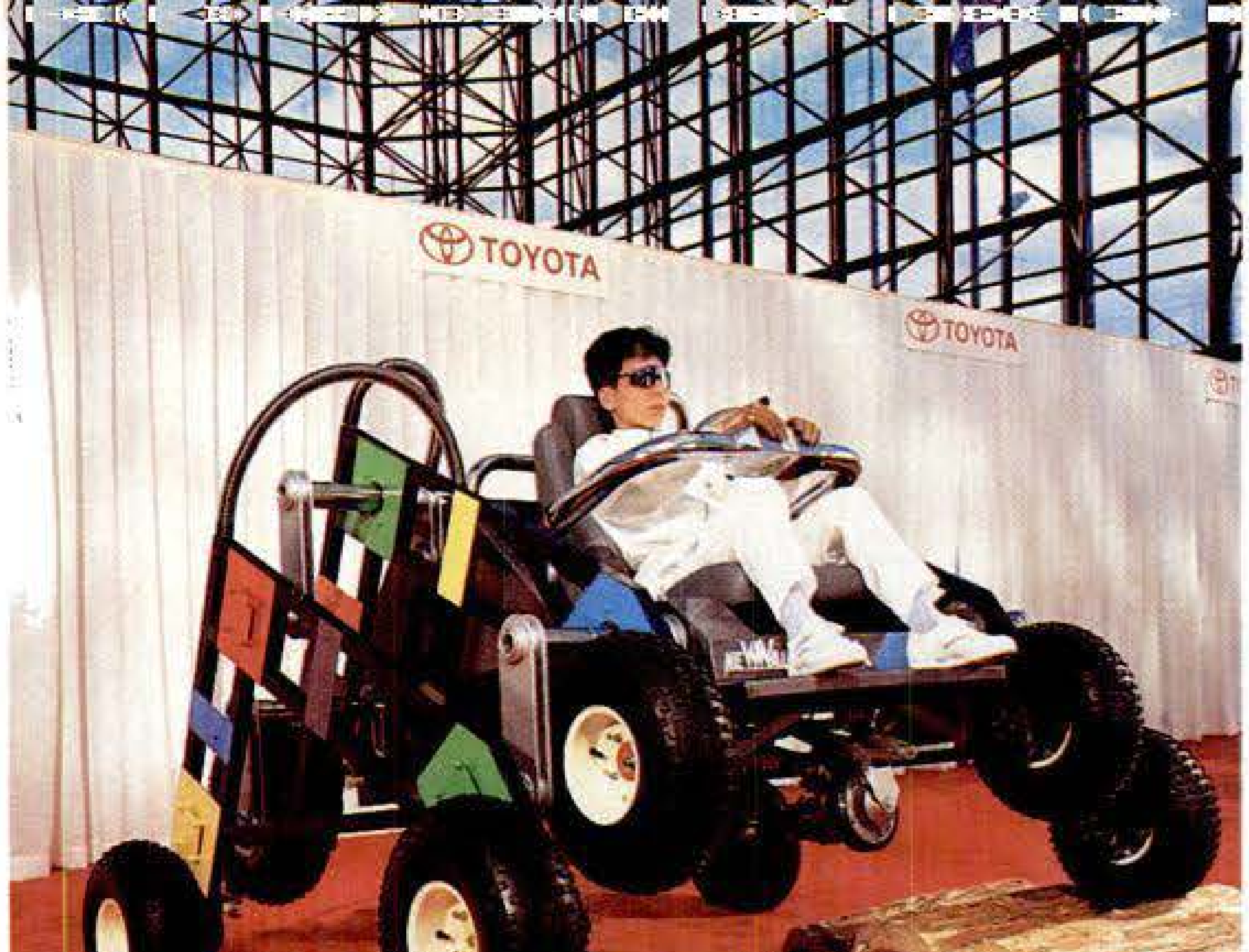
PHOTOS BY JOHN B. CARNETT

In Toyota's Idea Expo vehicle competition, teams are disqualified for being too serious or practical.

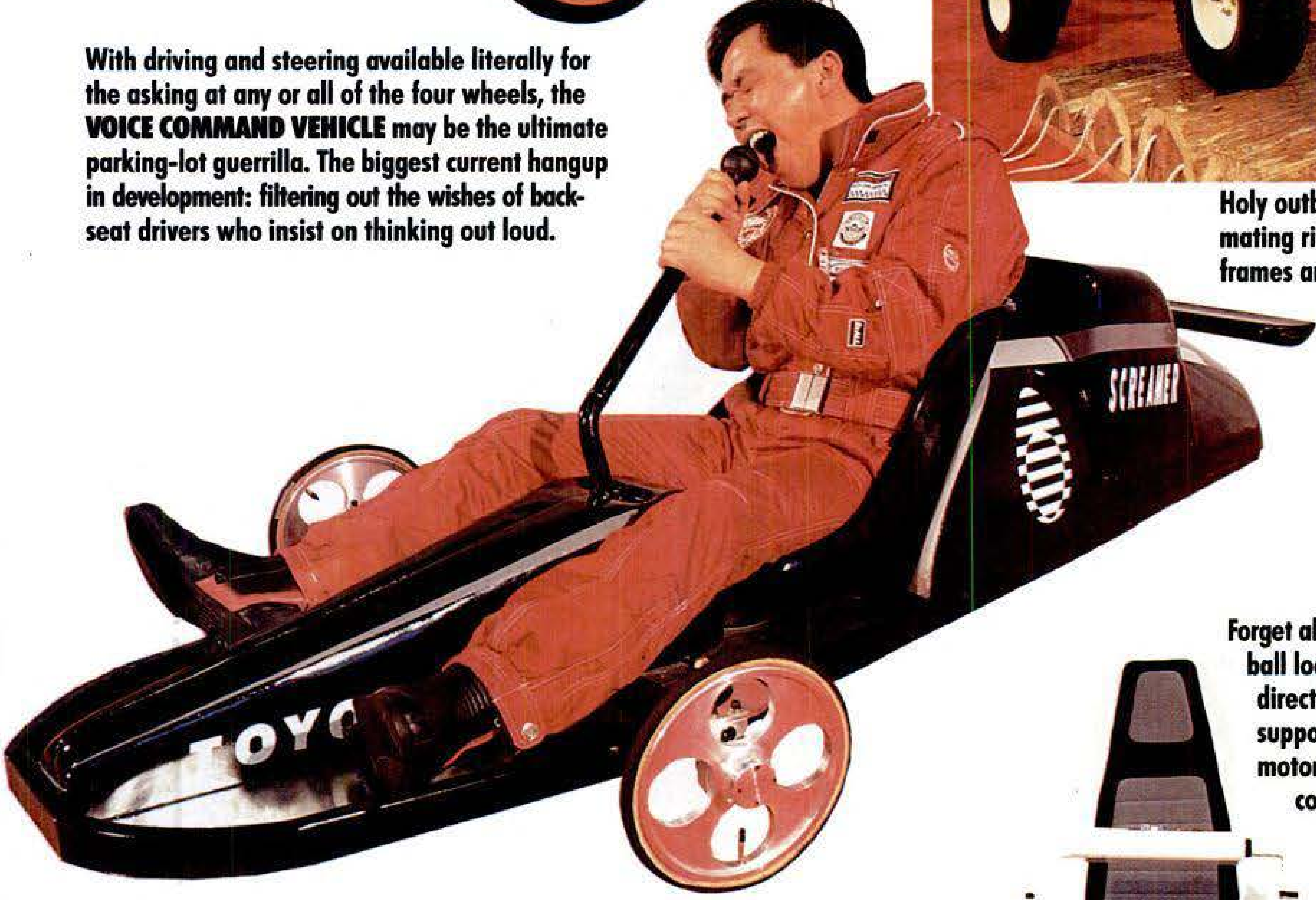
FUNNY



With driving and steering available literally for the asking at any or all of the four wheels, the **VOICE COMMAND VEHICLE** may be the ultimate parking-lot guerrilla. The biggest current hangup in development: filtering out the wishes of back-seat drivers who insist on thinking out loud.

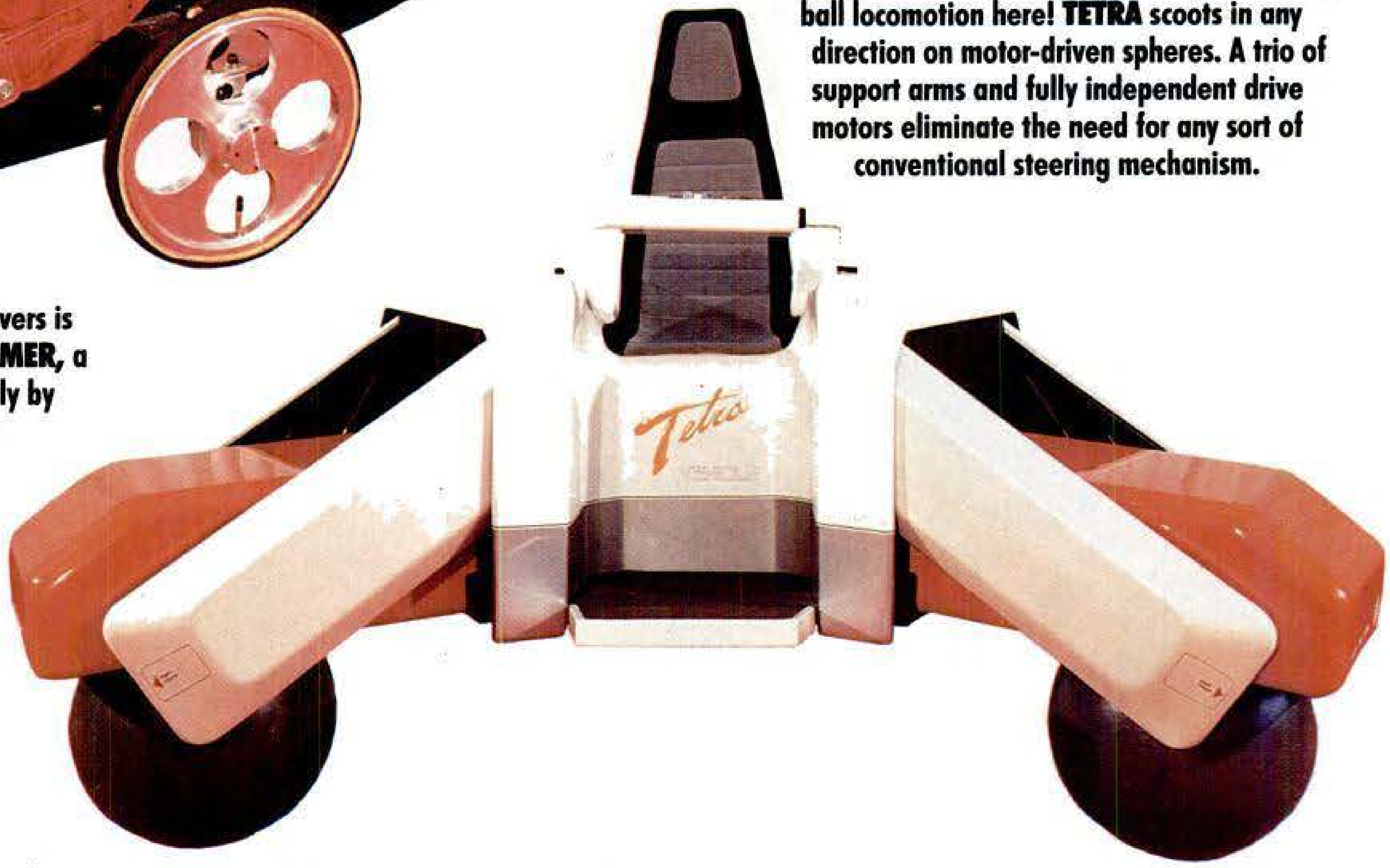


Holy outback, Martha! It's the rarely seen mating ritual of all-terrain vehicles! With two frames and nine wheels, the **NEW WALKER** leapfrogs one set of wheels at a time to amble over obstacles or turn in its own length.



Noise pollution emitted by gridlocked drivers is converted to useful energy by the **SCREAMER**, a single-seater that regulates speed entirely by the volume of the driver's voice. It works equally well in all languages, but self-control is strongly advised.

Forget about all-wheel drive, we've got bowling-ball locomotion here! **TETRA** scoots in any direction on motor-driven spheres. A trio of support arms and fully independent drive motors eliminate the need for any sort of conventional steering mechanism.



CARS

I've always figured that if you told a group of car engineers to put all seriousness aside, they'd end up drawing computer-generated happy faces on their pocket protectors. The winning entrants in a contest for Toyota engineers and technicians disprove my theory, though, with high-smileage alternatives to everyday transportation. Toyota sponsors the contest to encourage its engineers to stretch their imagination.—*Norman S. Mayersohn*

CAR MAKERS RACE TO PRODUCE TWO-STROKES

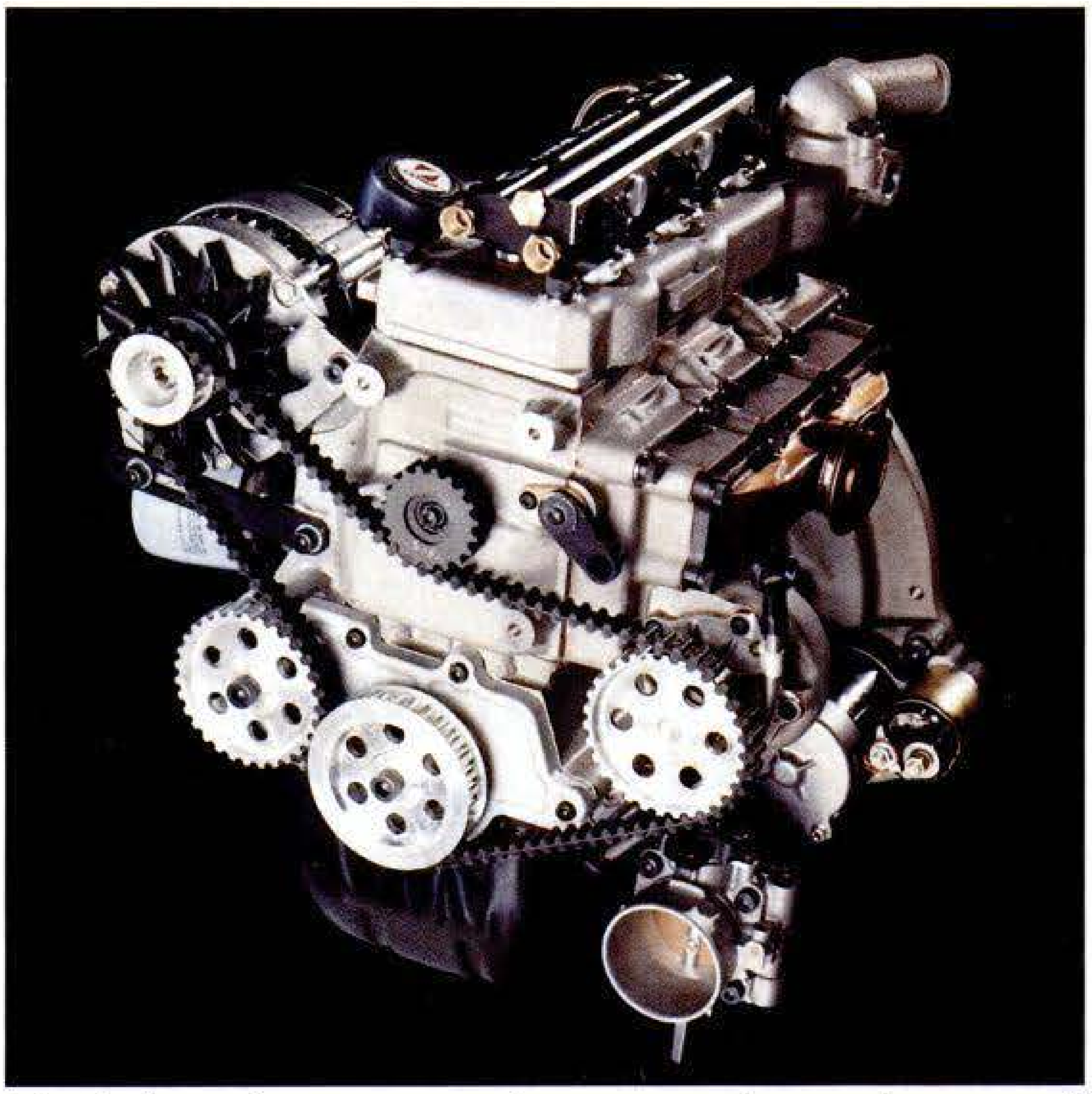
Small in size but big in output, new two-stroke engines promise a generation of tiny, super-efficient cars.

By DAN McCOSH

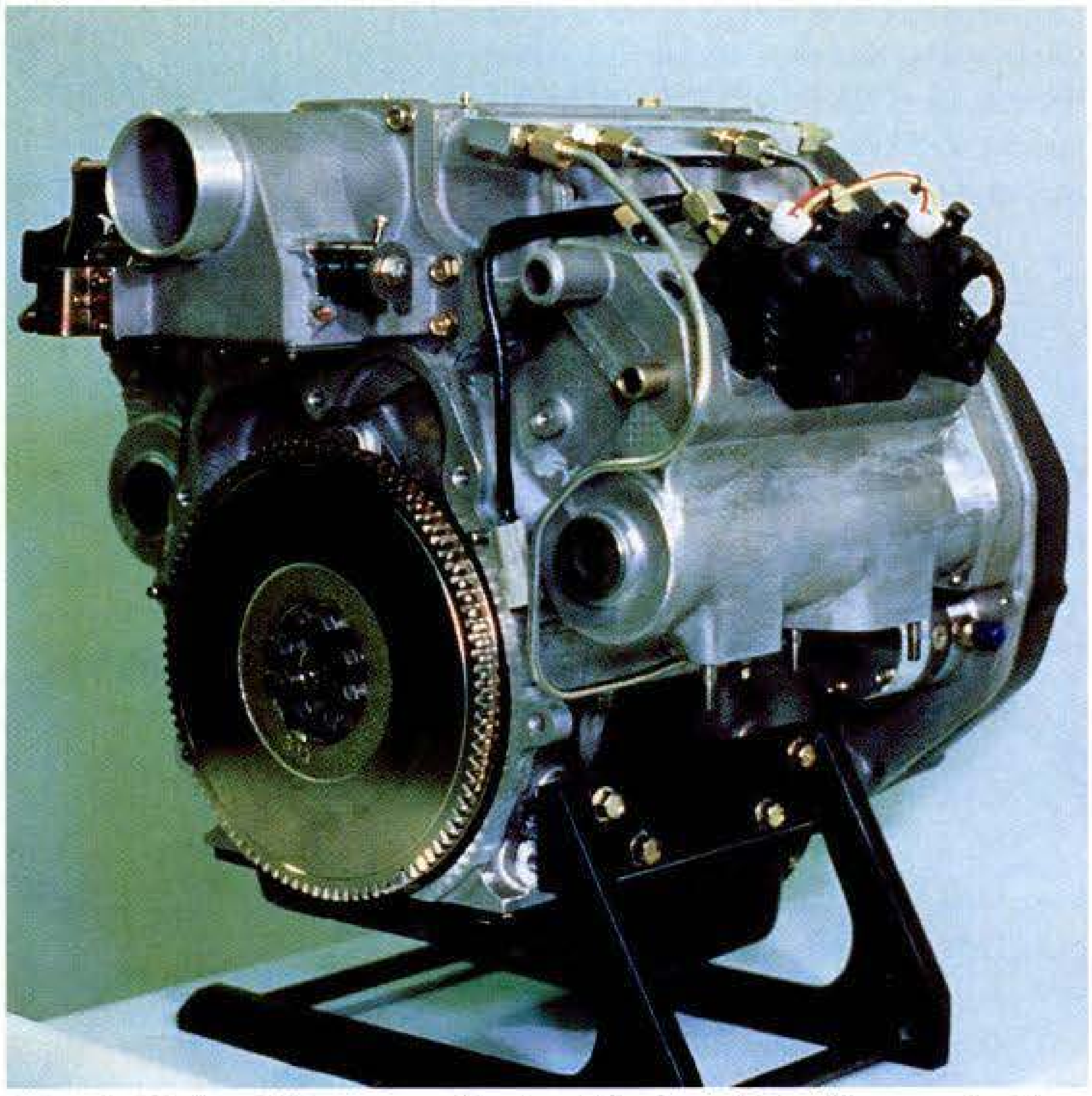
The significance of that mildly decrepit Ford Escort driving down a snow-dusted road in central Michigan wasn't apparent to the impatient pickup truck driver hanging close to my back bumper. The tailgater saw only an entirely unremarkable automobile from the outside, but under the Escort's hood was a tiny 1.3-liter two-stroke engine. This experimental engine has become the centerpiece of a feverish competition among engineering teams around the world to build a practical two-stroke power plant.

The truck driver was irritated because I was slowly accelerating from about 20 mph in fourth gear, deliberately lugging the prototype engine at a speed that normally would have the car snapping and jumping like a dog on a leash. Instead, it was ticking over smoothly, barely accelerating, with an exhaust note that had a sharp edge but no trace of misfiring. If only that truck driver knew it was the measured pace of automotive progress that was slowing his morning's work.

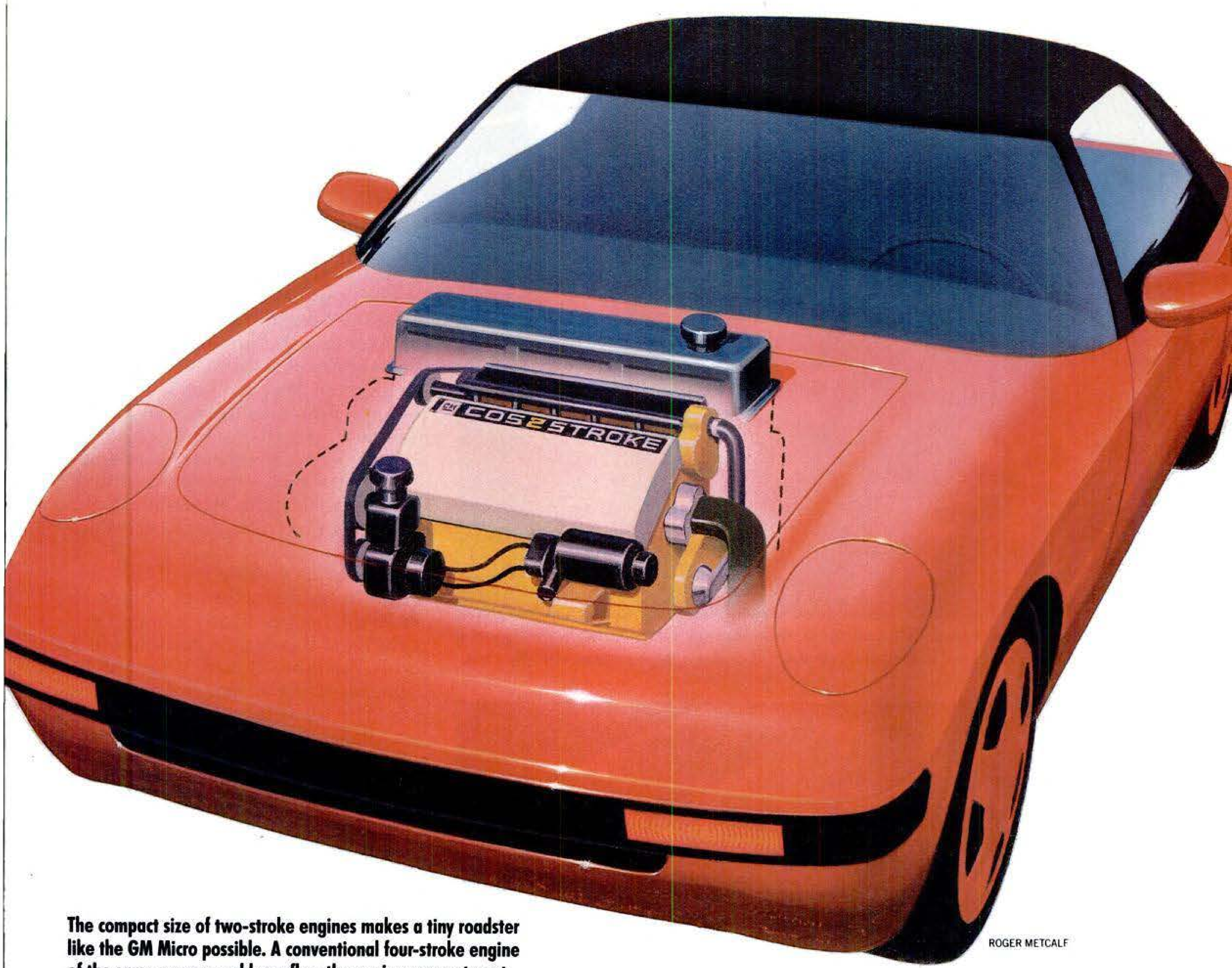
Even if my tailgater was up to date on the latest technology developments, it might not have been obvious to him why there's suddenly so much inter-



Orbital's latest design is a one-liter 116-pound externally scavenged three-cylinder that tucks the scavenge pump behind the flywheel to keep the overall package size small. Output is 90 hp at 6,000 rpm.



Subaru's 1.6-liter V4 is reportedly slated for installation in a small pickup truck by 1993. Less than 16 inches long from front to back, it uses a screw-type supercharger to produce 176 hp at 5,200 rpm.



The compact size of two-stroke engines makes a tiny roadster like the GM Micro possible. A conventional four-stroke engine of the same power would overflow the engine compartment.

ROGER METCALF

est in this longstanding two-stroke engine technology. The simple answer is that because a two-stroke power plant ignites fuel and generates horsepower every time a piston comes to the top of its stroke, it can produce more power per cubic inch of displacement than a four-stroke. It does not "waste" a stroke pumping out exhaust gases. Two-stroke engines are widely used in applications where light weight is a priority—everything from model airplanes to chain saws, and even a handful of automobiles.

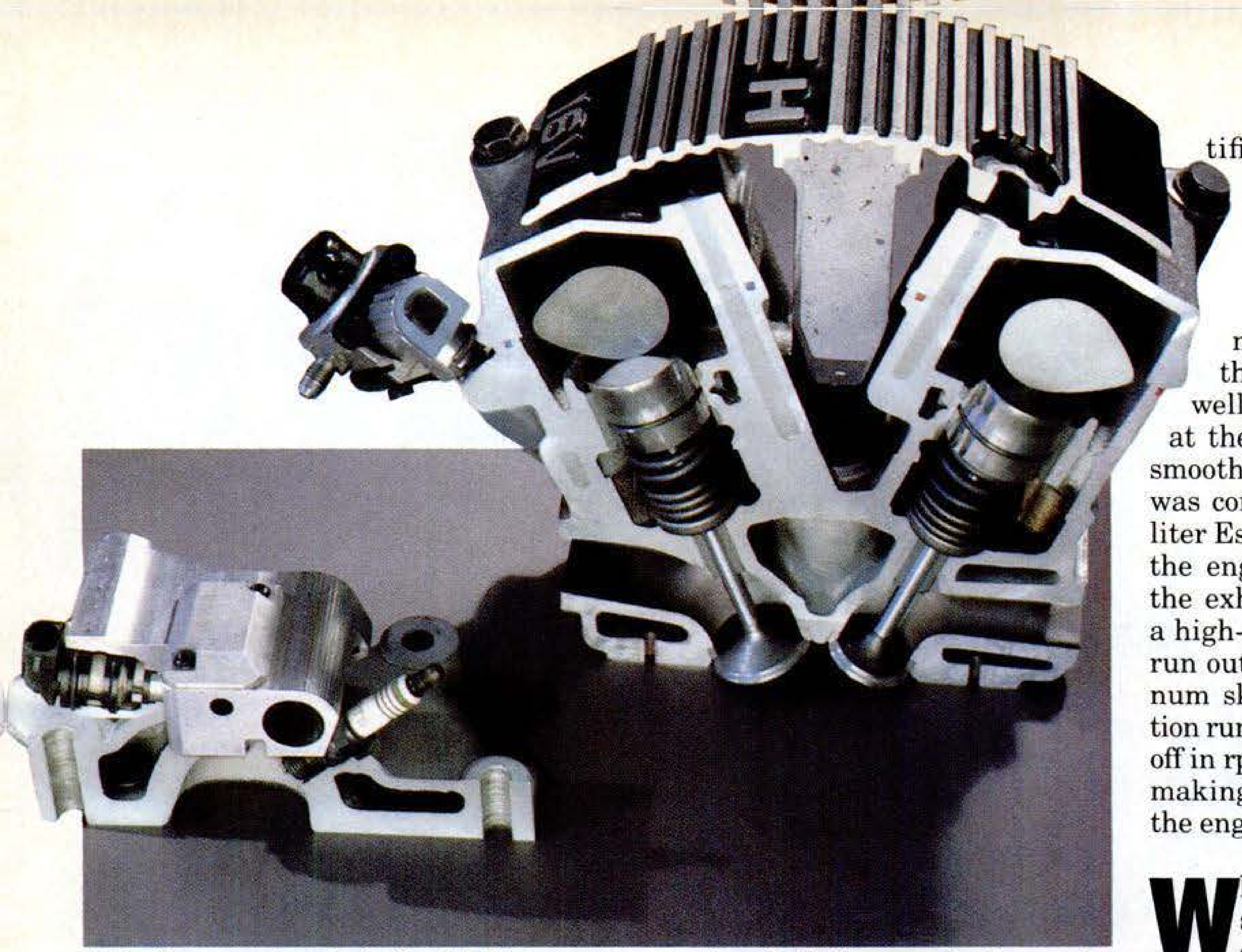
The four-stroke engine used in today's cars is something like a movie theater that clears all its patrons at the end of one showing before allowing any further seating. Two-stroke advocates say that's inefficient—let the new crowd in before the previous patrons leave. But with the crowd coming and going all at once, maintaining control can be difficult.

Up to now, most two-strokes have been extravagant with fuel, dumping prodigious amounts of the incoming air-fuel mixture out the exhaust ports unburned, making them both inefficient and extremely poor on emissions. Much of the promise of a two-stroke revival results from advances in microcomputers that make possible electronically controlled direct fuel-injection systems. The precise metering of these fuel delivery systems ensures clean, efficient combustion under all driving conditions.

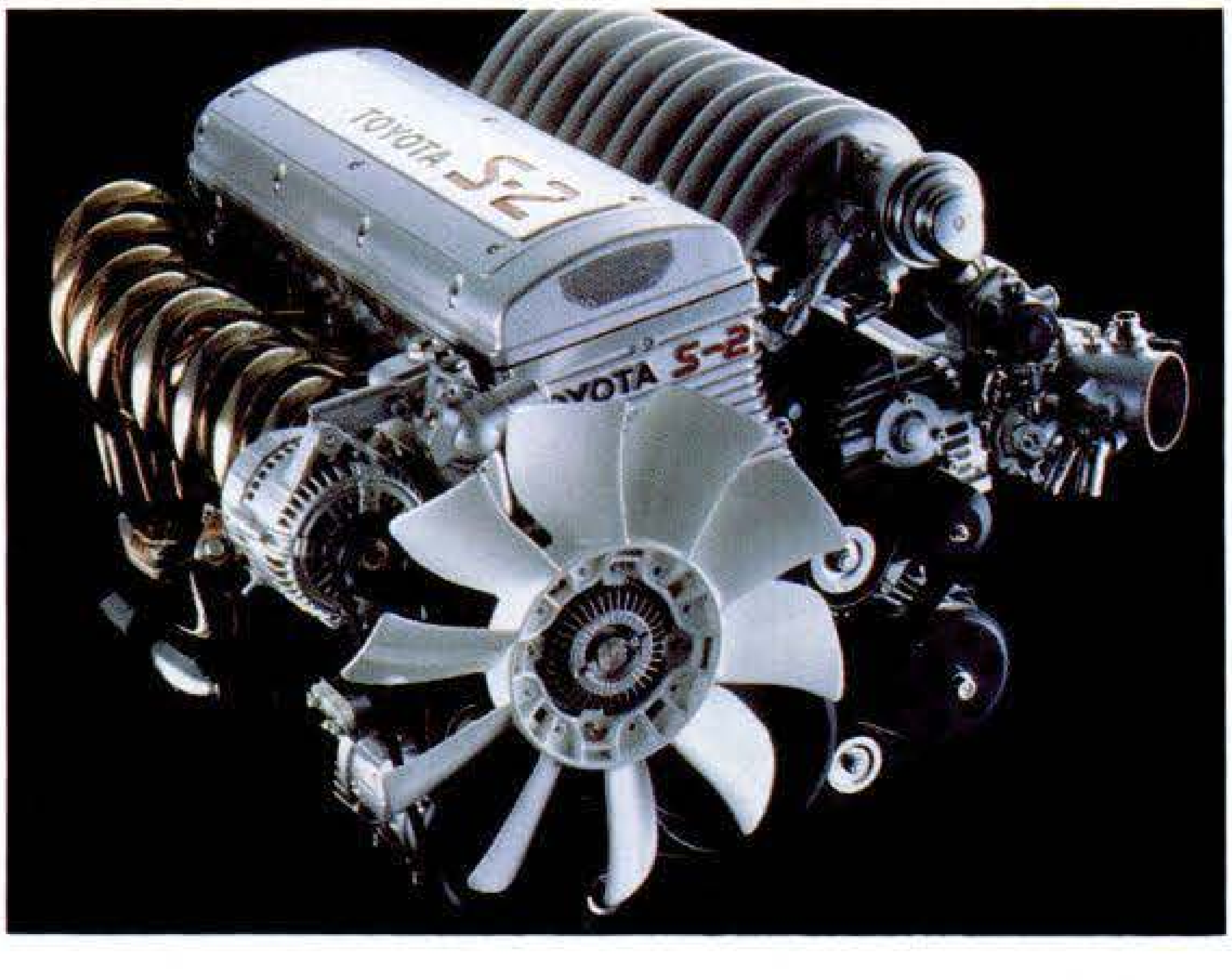
Today two-strokes are being touted as the engine of the future—inexpensive, lightweight, and compact because, in most cases, they do away with conventional camshafts, timing chains, and valves. In recent months, General Motors, Ford, Chrysler, Toyota, Subaru, Peugeot, and Volkswagen have given at least a teasing peak at their two-stroke research—some of it aimed at putting a mass-produced two-stroke engine on the road by the mid-1990s.

But there also are lingering doubts, reinforced by the recent sight of East German two-stroke Trabants crossing the border when the Berlin wall came down, puffing like a long row of smudge pots in a frostbitten orchard. Even more significant are the technical reservations over the two-stroke's potential superiority compared with advanced-concept four-stroke designs also anticipated by the mid-1990s. The uncertainty of future exhaust emissions regulations, especially over a 100,000 mile life span, has also kept engineers from throwing their entire research budgets toward two-stroke development.

The engine that started the furor —a prototype two-stroke developed by Australia's Orbital Engine Co.—was unveiled five years ago by inventor Ralph Sarich ["Can the Two-stroke Make It This Time?" Feb. '87]. It features a unique low-pressure, direct-injection fuel system. Orbital is expected to begin building automotive two-strokes within a year at a new plant near Cass City, Mich. Development of the engine is ongoing in a



While the two-stroke cylinder head (left) contains no more than the fuel-injection hardware and a spark plug, a GM Quad Four head is comparatively tall and carries a large number of costly parts.



Toyota's supercharged in-line six is enormous and complex, but its smooth operation and impressive power levels could lead to usage in a new full-size pickup truck.

joint venture with Walbro Corp., a major manufacturer of automotive fuel-delivery systems.

It was in Walbro's dynamometer lab that I received a short course in what the modern two-stroke controversy was all about.

Stripped to its basics, the two-stroke engine is deceptively simple. Each cylinder is closed at the top, with no valves or conventional air or exhaust passages in the cylinder head. Air intake and exhaust flow occur through slotted ports in the cylinder wall that are uncovered by the piston near the bottom of its stroke: the exhaust port first, followed by the uncovering of the intake slot. After the exhaust port is opened, air pressurized in the crankcase blows into the cylinder, displacing exhaust gases.

This is also the stage where the Sarich engine design differs from your chain saw. Most two-strokes pump an air-fuel mixture through the crankcase rather than air alone as the Orbital design does. In this new design, fuel is injected later in the rotation, after the air intake port closes, by an unusual fuel injector that blasts air through a small gasoline reservoir in the cylinder head.

The air atomizes the fuel, while the fuel control system oversees both the shape and timing of the charge. By the time the charge is ignited at the top of the stroke, the fuel charge is theoretically capable of burning at an extremely lean mixture, ignited in layers, starting with a richer mix at the spark plug. This so-called "stratified charge" burning allows nearly complete combustion before the exhaust port opens—the secret to the engine's efficiency.

It's a delicate balance to maintain, but my drive proved that the development process is well along. The prototype started at the first touch of the key, idling smoothly when cold, and the torque was comparable to the standard 1.9-liter Escort engine. The first hint that the engine was different came from the exhaust note when accelerating, a high-pitch drone I'd last heard on a run out to the pike beds in an aluminum skiff. Another glitch: Acceleration runs were marred by the slow drop-off in rpm when the throttle was lifted, making quick shifts impossible. Still, the engine was tractable and drivable.

While convincing me of the two-stroke's practicality, the drive did not reveal any inherent superiority of this design. For that I had to lift the hood: It took a minute to appreciate the compact size of the engine. There was room for a small suitcase alongside the diminutive three-cylinder engine—in space saved when the original four-cylinder power plant was replaced. The small size and considerable weight savings—over 200 pounds in this case—are the factors that excite most automotive engineers.

The package seems ideal for a small economy car—which is where most auto makers investigating two-strokes seem headed. GM, which has licensed the two-stroke Orbital technology and incorporated it in an engine of its own design, displayed a prototype engine in a tiny roadster at the 1990 Detroit Auto Show. Ford, likewise, is working on a small car for the European market. Japan's Subaru seems bent on reviving a version of the two-stroke minicar it had on the road through 1972.

The high hopes for two-strokes have been derailed several times, though. Most of the technical issues over valving, scavenging, lubrication, and exhaust tuning were well in hand by the mid-1930s, but the promise of lightweight horsepower has been continually thwarted by poor fuel economy, traceable to the basic concept of the engine.

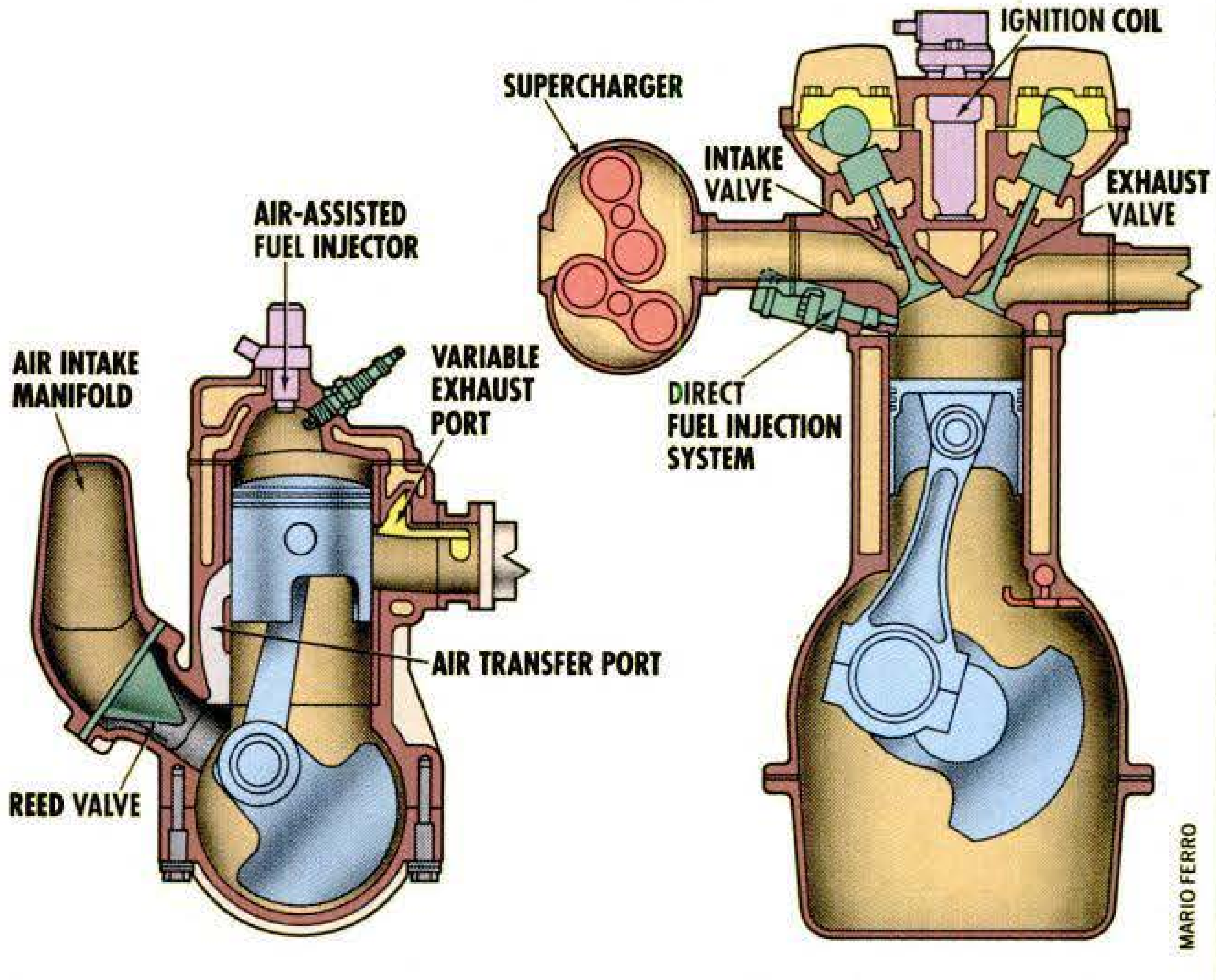
To allow an engine to fire every stroke, it must complete the power stroke, evacuate the exhaust gas, replenish the cylinder, and begin a compression stroke in about 270 degrees of crankshaft rotation. Much of this is attempted simultaneously, with a corresponding interference of one stage against the other.

Two-stroke engine design thus concentrates on gas-flow management, the art of simultaneously exhausting the cylinder on one side while admitting a fresh air-fuel charge on the other. Inevitably some mixing occurs as fresh fuel exits when the exhaust port opens or some leftover exhaust remains trapped after it closes. One solution proposed by designers involved directly injecting fuel into the cylinder, ending the crowd-mixing action during the intake-exhaust stage. Fresh air could do its thing, evacuating exhaust and recharging the cylinder, then fuel would be added after the ports are closed.

But to make this work over a full rpm range, the injection timing needs to be precisely controlled. Optimally, variable timing of all three elements of combustion—exhaust, air intake, and fuel injection—promises the most efficient burning of the fuel and corresponding lower exhaust emissions. The problem was that no such control method existed in the pre-microelectronics era.

Australian inventor Sarich was an early rotary-engine advocate and spent a dozen years attempting to perfect a seven-lobe rotary engine similar in principle to the Wankel. Embroiled in financial controversy, the original Orbital design died, but Sarich resurrected its fuel-delivery system—a low-pressure fuel-injection system that blasts air and fuel together directly into the cylinder—and applied it to a simplified two-stroke design based on a three-cylinder Suzuki outboard motor engine. It proved to be a great leap forward.

THE EXTREMES OF TWO-STROKE ENGINE DESIGN



The simple and compact Orbital two-stroke (left) routes intake and exhaust airflow through port "windows" cut into the engine block cylinder walls. The opening and closing of the ports is regulated by the vertical position of the piston, while the fuel is sprayed directly into the combustion chamber by an air-assisted injector. In Toyota's two-stroke design, airflow is directed through conventional ports and valves in the cylinder head, assisted by a positive displacement supercharger.

"The difference was electronics," Roger Heimbuch, executive engineer for power trains at GM, told me. "To control combustion, you needed to control the timing and spray pattern of the injection system carefully. It takes electronics to do that." Today electronic direct-injection systems are a central theme in all the pending two-stroke designs, whether or not they use or license the Orbital technology.

Beyond the agreement on the need for some kind of direct injection, other design issues remain unsolved. Various alternatives have to be weighed on the merits of cost versus efficiency, with numerous tradeoffs between performance and complexity.

The basic thrust of the Orbital program, currently licensed by both GM and Ford, is simplicity and low cost. Early Orbital designs used crankcase pressure (generated by the underside of the downward-moving piston) to transfer air into the cylinder. Timing of intake air and exhaust is via ports in the cylinder wall that are uncovered as the piston goes through its motions. It's a standard solution, common to outboards and model airplane motors, but it has limitations.

Using the crankcase as an air pump prohibits using a pressure-fed wet-sump lubrication system, so the early Orbital engines featured roller-bearing crankshafts and a total-loss oil system that threatened to pollute the catalyst with excessive oil. Chrysler recently showed a promising alternative, an engine that uses a belt-driven centrifugal supercharger (something like half a turbocharger) that routes intake air clear of the crankcase and allows use of conventional bearings and a wet sump. This external scavenging design is a tidy approach and opens the possibility of future positive-boost supercharging. The added bulk of the external blower does increase the size of the engine, however, and that creates a packaging problem in small cars.

Then Toyota threw them all a curve at this year's Tokyo Motor Show when it casually unveiled an elephantine two-stroke engine based on a three-liter in-line six-cylinder block. The valve cover alone was nearly big enough to house Orbital's diminutive engine, and an external supercharger added even more bulk. This Godzilla two-stroke produces an astounding 235 hp at 3,600 rpm, with a torque peak of 362 pound-feet at 2,800 rpm. With dual-overhead camshafts, four valves per cylinder, twin fuel injectors, twin air pumps, and a promise of new catalytic technology, it's a marvel of complexity—and obviously is not slated for a minicar. The existence of this engine has led to speculation that Toyota is using two-stroke technology to develop quickly a truck engine competitive with a large-displacement V8, something it would need to enter the full-size pickup market.

Inlet air is fed through a Roots-type blower, and lubrication is via a wet sump. It's an interesting approach from the theoretical standpoint because camshafts can provide more-precise timing of intake air and exhaust than fixed ports in a cylinder wall. Furthermore, the elimination of the intake and exhaust ports that would normally surround the cylinders allows the engine block to be more compact. The engine's overall height, though, is increased with the addition of a valve train on top.

"We felt that there is a lubrication problem with the intake ports in the cylinder walls scraping oil from the rings," says Akihiro Wada, Toyota Motor Co.'s director of front-wheel-drive vehicles, arguing the case for the valve-in-head design. "Also, we already have the machinery in place to make such an engine."

G. E. Hundleby, in charge of gasoline engine research at Ricardo Engineering in England, argues for just

[Continued on page 94]

LOOK WHO'S CALLING

When this telephone rings, a built-in screen displays the caller's number. Caller identification is a controversial new service made possible by advanced signaling systems in the phone network.

HUGO SALHUANA

By DAWN STOVER

Last autumn, law enforcement officials in Essex County, N.J., were hunting a man who had allegedly sexually assaulted a seven-year-old boy. Their suspect lived in Westfield, N.J., so they notified the Westfield police that an arrest warrant had been issued.

The wanted man later telephoned the Westfield Police Desk, said he was at home, and asked why the police were looking for him, Capt. John P. Wheatley noted. But one glance at a paperback-size box connected to the station's phone told Westfield officers the man was lying. The device displayed the caller's telephone number—and according to the first three digits, which indicate the exchange, the man was in Plainfield, N.J., not Westfield. "The telephone company informed us that the number was from a convenience store phone booth," wrote Wheatley. The suspect was soon under arrest.

The caller identification device used by Westfield police doesn't require a special phone line, and the service—Caller ID—is now available to residential customers and small businesses. Phone companies claim that Caller ID, the most popular of a variety of new "intelligent" services, not only catches criminals and deters obscene phone callers, but can even save lives. But not everyone agrees that Caller ID is a good idea.

Others argue that the service threatens privacy by disclosing phone numbers, including unlisted ones, and might even endanger lives. For instance, a social worker who counsels disturbed patients, and sometimes calls them from her home, worries that a violent client will learn her number and thus her address. And a detective who does undercover work also fears his home number will be revealed. Balancing the privacy concerns of the caller and the person called is the challenge facing public officials who must decide the fate of this new technology.

A primitive form of caller identification existed in the early days of telecommunications. "You talked to an operator to make a call," says Steven Zachok Jr., director of services and technical planning at Bell Atlantic. "The operator knew everyone's voice and often announced their calls." But as the phone system grew, the human operator was replaced by mindless electromechanical switches. "Tracing" a call through the maze of electrical contacts between two people meant keeping a caller on the line as long as possible.

Two-party system

In the mid-1980s phone companies began installing an internationally standardized system called Signaling System 7. The SS7 system increases a network's efficiency by sending call setup information and voice transmissions along separate routes (see drawings on page 78). Each call message sent via SS7 includes the numbers of both parties. That information could be sold to customers, reasoned Bell Atlantic's New Jersey Bell, which began offering Caller ID in Hudson County and Atlantic City in 1987 and throughout the state by 1988. In recent months Caller ID became available in parts of Virginia, West Virginia, Maryland, Tennessee, and Vermont. It will soon be available in Florida.

To view callers' numbers, which are transmitted during the lull between the first and second rings, custom-

ers must subscribe to the ID service (about $6.50 a month) and purchase special hardware. Earlier this year, Northern Telecom introduced the Maestro, a $136 phone with a built-in display panel (see photo).

Sears and a variety of other stores also sell display units that connect to existing phones. Made by Colonial Data Technologies (CDT) of New Milford, Conn., the add-on devices cost about $80 and store the numbers of answered as well as unanswered calls. That means you can call back the person who left an unintelligible message on your answering machine—as well as someone who didn't leave a message at all.

Benefits . . . but at a price

In New Jersey more than 40,000 customers already subscribe to Caller ID. Police and fire officials, among the first to sign up, say the system has helped them curb false alarms—saving taxpayers the expense of dispatching emergency services.

Schools and businesses have also benefited from Caller ID. St. Peter's College in Jersey City, for example, hasn't had any bomb threats since it began using Caller ID. Pizza parlors, florists, taxi services, and repairmen can also verify phone numbers, thereby reducing the incidence of phony orders and robberies.

Most residential customers subscribe to Caller ID for a different reason—to cope with annoying or obscene calls. A 1988 survey of more than 1,600 New Jersey customers found that 42 percent had received annoyance calls in the past year. "Just by having the service in place," says Zachok of Bell Atlantic, "the public is getting protection they didn't have before."

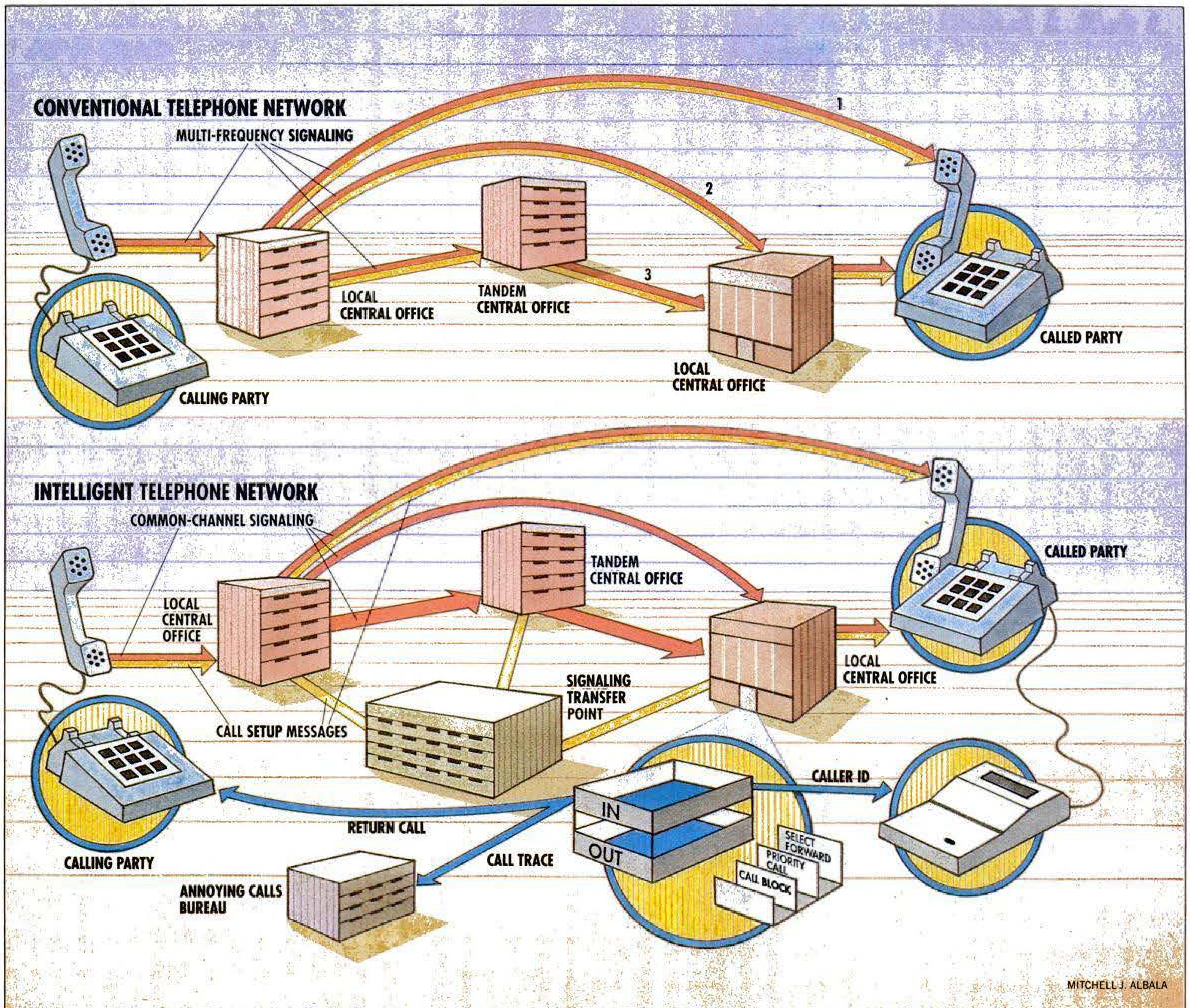
But Caller ID doesn't necessarily eliminate harassing calls. Anyone determined to remain anonymous can easily call from a pay phone. And according to its critics, Caller ID could actually cause more annoying calls to your home. How?

Many large businesses with toll-free lines already use automatic number identification services (offered by long-distance carriers such as AT&T, MCI, and US Sprint) to expedite telephone transactions. Call American Express or J. C. Penney to inquire about your account, and a representative usually has your name, address, and balance up on a computer screen before even answering the phone. That speeds the process, but it could work against you too. Ask for information about a product, and the request might expose you to future calls from a persistent salesperson. Worse yet, your number could be added to a telemarketing list sold to other companies.

The NAACP and other organizations fear the ability to trace numbers could lead to discriminatory redlining. For example, landlords

JOHN B. CARNETT

Northern Telecom's Maestro remembers the numbers of up to 15 unanswered calls.



MITCHELL J. ALBALA

In a conventional telephone network, dialing a number sends a signal to the local central office. If the called party has the same exchange, the call can be routed directly to his phone **1**. If not, the call may be routed through another local office **2** or along a trunk line to a tandem central office linking local offices **3**. The multi-frequency signals traveling between the two parties consist of audible tones that carry the call setup information (yellow) as well as the conversation itself (orange). A conventional network is inefficient, because only about 70 percent of all calls are completed. Yet calls that end with a busy signal or no answer still tie up the entire pathway between the two parties.

An "intelligent" phone network, called Common Channel Signaling System 7, carries conversations along the same routes as in a conventional network, but speech signals are held until both parties are on the line. First, basic information about the call travels to a signaling transfer point (STP), a switch matrix that selects and confirms connections between computerized switches at the central offices. When everything's ready, the STP activates the call.

The call-setup messages sent to the STP include the phone numbers of both parties. Those data can be stored in computer memory slots at local central offices and passed along to customers who pay for special services. One memory slot holds the number of a customer's last outgoing call; that can be used for automatic redialing (Repeat Call). Another slot holds the number of the last incoming call; a customer can use it to return a call when he doesn't know who called (Return Call). Or he can press a special code to have the number recorded at a bureau that handles annoying calls (Call Trace). With Caller ID, the most popular service, a customer can have the numbers of incoming calls transferred to a display device in his home.

Some memory banks at the local central office hold lists, rather than single numbers. A customer can store up to six numbers in each of these lists: Call Block (calls from the designated numbers are rejected), Priority Call (calls from these numbers are given a distinctive ring), and Select Forward (calls from these numbers are forwarded to another phone).—*D. S.*

might opt to ignore calls from certain neighborhoods.

Edward Martone, executive director of the American Civil Liberties Union of New Jersey, says that Caller ID will also have a chilling effect on hot lines. "People will not make calls that they really should make," Martone says. They might hesitate to report a neighbor for child abuse or call the health department or tax office for information, he says. "Not all people who make anonymous calls have illicit purposes," he adds.

Martone also sees a contractual problem with Caller ID: "Folks who pay for a private line are paying extra money for that service." Caller ID leaks their unpublished numbers without compensation.

"Think of a telephone as a door," said Ian Craig, vice president of marketing for Integrated Network Systems at Northern Telecom, upon introducing the Maestro Caller ID phone. "[Maestro] gives us a door with a peephole... It will soon be as unthinkable to answer your phone without looking to see who's calling as it

[Continued on page 95]

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HIGH-FIBER HOUSE

Fiber-concrete wall panels containing anything from wood chips to peanut shells are glued together to form affordable houses.

By CHERYL M. FIORILLO

The National Association of Home Builders reports that first-time home buyers today typically spend 33 percent of their annual household income on housing; that's up from 18 percent 20 years ago. The result is that many would-be home buyers are priced out of the market; their dream of owning a home is simply that—a dream.

Now a company called Acotec (Advanced Construction Technology) in Scottsdale, Ariz., is seeking a market niche by making dreams of affordable housing come true. Acotec, a branch of a Finnish company with the same name, builds the equipment to make concrete tongue-and-groove panels, which are glued together to form a house. Construction takes little time —and little skill; it is well within reach of an average do-it-yourselfer, the company claims.

The panels themselves are unusual. Natural fibers—rice husks, peanut shells, waste paper, wood chips—are mixed into the concrete. That lightens the weight of the panels, increases their ductile and tensile strength, and enhances the workability: Conventional nails and screws can be used, and sawing is easier, explains Päivi Talonen, marketing manager of the parent company. Like conventional concrete, Acotec panels are noncombustible, weather resistant, and unappetizing to insects.

Natural-fiber concrete was developed by Professor Asko Sarja, director of the Concrete Silicate Laboratory at Finland's Technical Research Center in Helsinki. Sarja is a consultant to Acotec, founded in Finland in 1986. The American company was launched two years later. It has a prototype manufacturing facility, formerly in California but now in Florida, and a demonstration house in Phoenix.

In the manufacturing plant, wood chips—17 percent by volume—are mixed into the concrete. Panels two feet wide and three or four inches thick are extruded onto steel plates and cut to any length up to 10 feet. (Those used in the demonstration house are eight feet long and three inches thick.) Once the panels are cured and dried, they're shipped to the job site and glued together to form a house (see box).

All else being equal, using wood chips in the concrete mix enhances its tensile strength and ductility by a factor of two to three, depending on the specific mix, according to company tests. The reason, explains William G. Barrett, Acotec's technical supervisor, is that the cement in the mix bonds tenaciously to the wood fibers because of their porosity. Increased tensile strength means the fiber concrete better resists forces that would tend to pull it apart; enhanced ductility means it is not as brittle as conventional concrete.

Compressive strength of the fiber concrete is about 15 percent lower than that of conventional concrete, Barrett notes. Panels used in the demonstration house measure around 1,800 psi. "That's way more than adequate for a single-story house," he points out. The panels also can be used to construct two-story buildings, but Acotec does not recommend them for taller buildings.

The house in Phoenix is built to California's strictest seismic code, which meant placing the steel tie-down rods every four feet. These are not reinforcing bars; they anchor the roof to the foundation, but do not contribute significantly to the strength of the walls.

Outside insulation

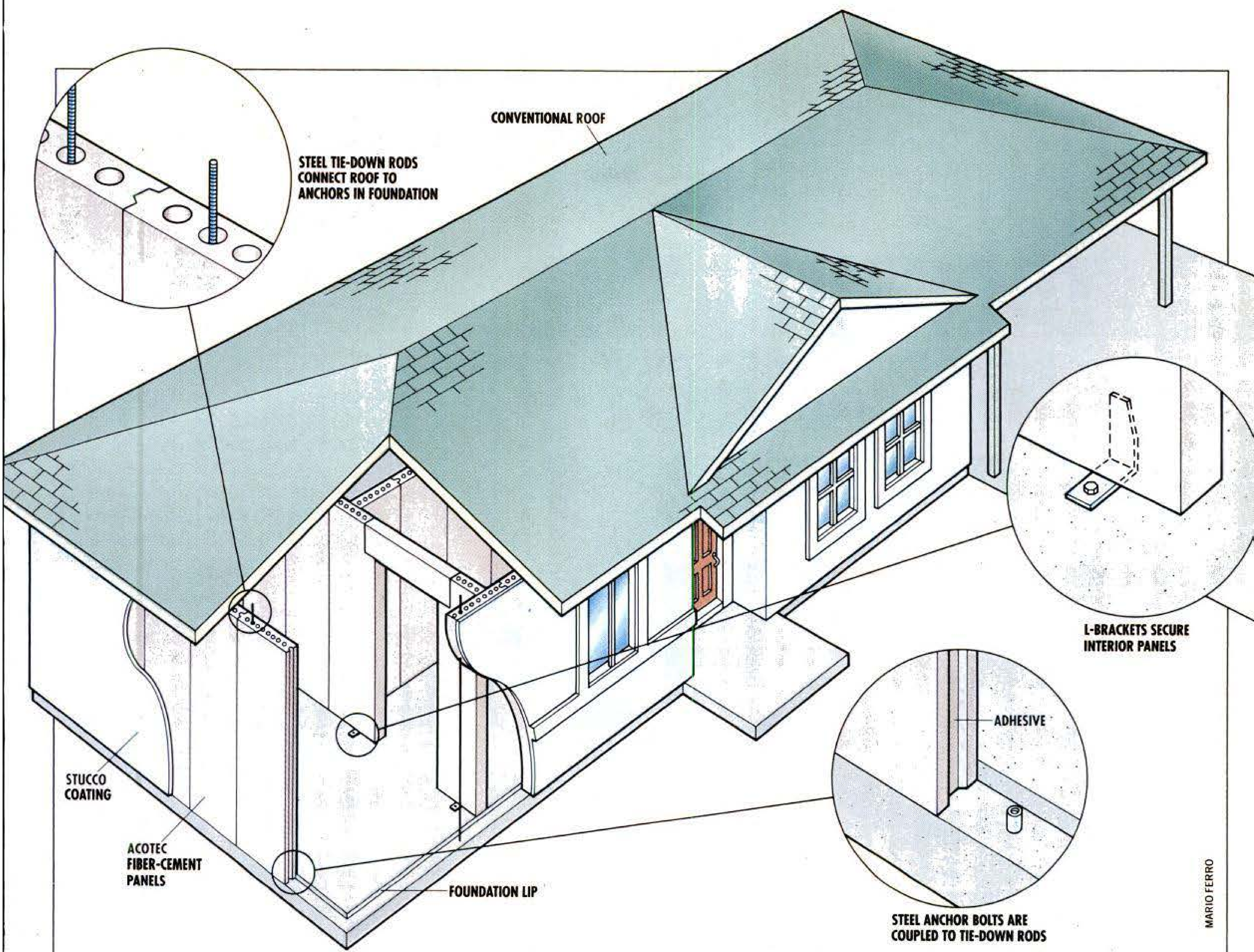
Adding fiber to the concrete does little to improve its insulation value. The three-inch-thick panels used in the Phoenix house measure only R-2.23, so rigid foam insulation is added. The type and thickness can be chosen to suit the climate. Expanded-polystyrene insulation was used on the Phoenix house; R-values of the finished walls range from 11 to 14, and one section was left uninsulated for test purposes.

The insulation is nailed to the outside of the house. That puts the concrete walls inside the insulation, where they serve as thermal mass. "The walls are slow to heat up and slow to cool down," says Barrett. In a climate like Arizona's, where days are hot but nights cool, that can save significant energy by leveling out interior temperature swings.

A modest 1,600-square-foot conventional house in Phoenix (not including the lot) costs approximately $38 per square foot to build, according to R. L. Brown, publisher of the "Phoenix Housing Market Letter," a newsletter for builders. The Acotec demonstration house was built for about $25 per square foot (excluding the lot).

The primary reason for the savings: reduced labor costs. "The Acotec house goes up about five times as fast as a conventional stud-wall or concrete-block house," Barrett says. Fewer workers are needed—and few high-priced skilled workers are required.

Acotec has been approved by the Department of Housing and Urban Development. That means government-subsidized low-interest loans can be used to purchase the homes. The company has manufacturing plants slated for Detroit and Phoenix, and negotiations are under way to sell panel-making equipment to one California company and another in Georgia. PS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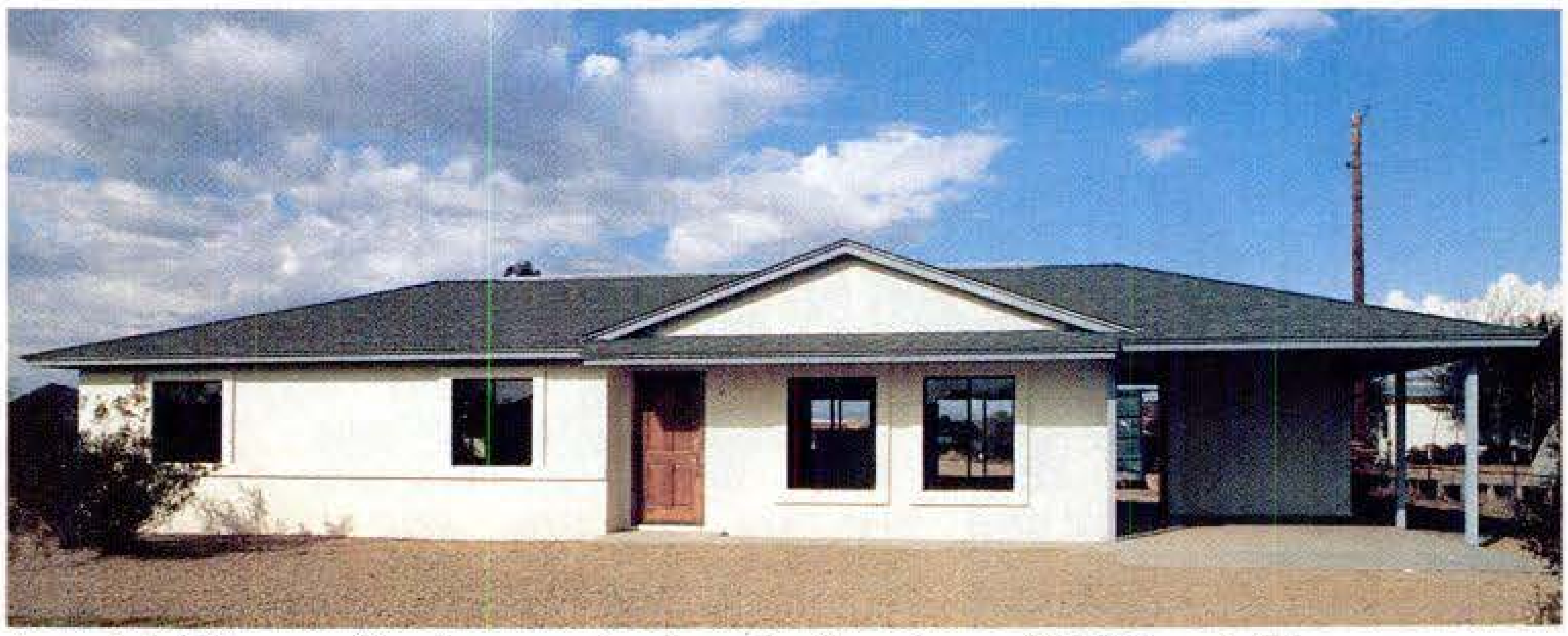
GLUED-TOGETHER HOUSE


Acotec's 1,256-square-foot demonstration house in Phoenix cost $30,000 to build.

Acotec fiber-concrete panels fit together, tongue-and-groove fashion, to form a house. The only tools needed are epoxy construction adhesive, pry bars, wood for bracing and shimming, and a 13-inch circular saw with diamond-tipped blades. (Carbide blades can be used but they'll dull faster.)

An Acotec house starts with a concrete slab or foundation—conventional except for a recessed lip around its periphery. Steel anchor bolts are embedded in the lip. Once the slab is prepared, a crewman applies a bead of adhesive along the lip, then two workers lift an Acotec panel into place, starting at a corner. (Corners are simple butt joints formed with adhesive; the protruding tongue of one panel must be sawed off.)

Next, steel tie-down rods are placed. One crewman raises the panel with a pry bar while a second steadies it. A third, on a ladder, drops threaded steel rods through the hollow cores in the panel. (Rod spacing depends on local codes.) A fourth worker uses couplings to connect the tie-down rods to the anchor bolts in the slab. Temporary wood bracing holds the panel in place.

Once two corner panels are installed, a double bead of adhesive is snaked along one panel's edge and two workers lift a third panel into place, pushing its tongue firmly into the mating panel's groove. Then tie-down rods are placed as before. The remaining panels are then erected in a similar fashion.

After the walls are up, an electrician runs the wiring through empty hollow cores in the panels (seen from the top in the lower right photo). Most water lines, too, are run through the cores. Waste lines run through the slab or basement. The roof is conventional: Wood trusses or rafters attach to a 2×4 top plate, which is drilled to receive the tie-down rods.

Interior walls, also Acotec panels, are attached with special L-brackets, which are riveted to the floor. Inside walls are plastered, then finished with paint, wallpaper, or paneling. Rigid foam insulation is nailed to the outside of exterior walls, then stucco, siding, or brick veneer can be put on to finish the house walls.—*C. M. F.*

TACKLING THE MENACE OF SPACE JUNK

Mankind has deposited over 6.5 million pounds of garbage in space, and even microscopic bits of debris can disable spacecraft. Experimental defenses include sweaterlike shields and a "bomb shelter" for the space station.

By MARK D. UEHLING
Illustrations by Vincent Di Fate

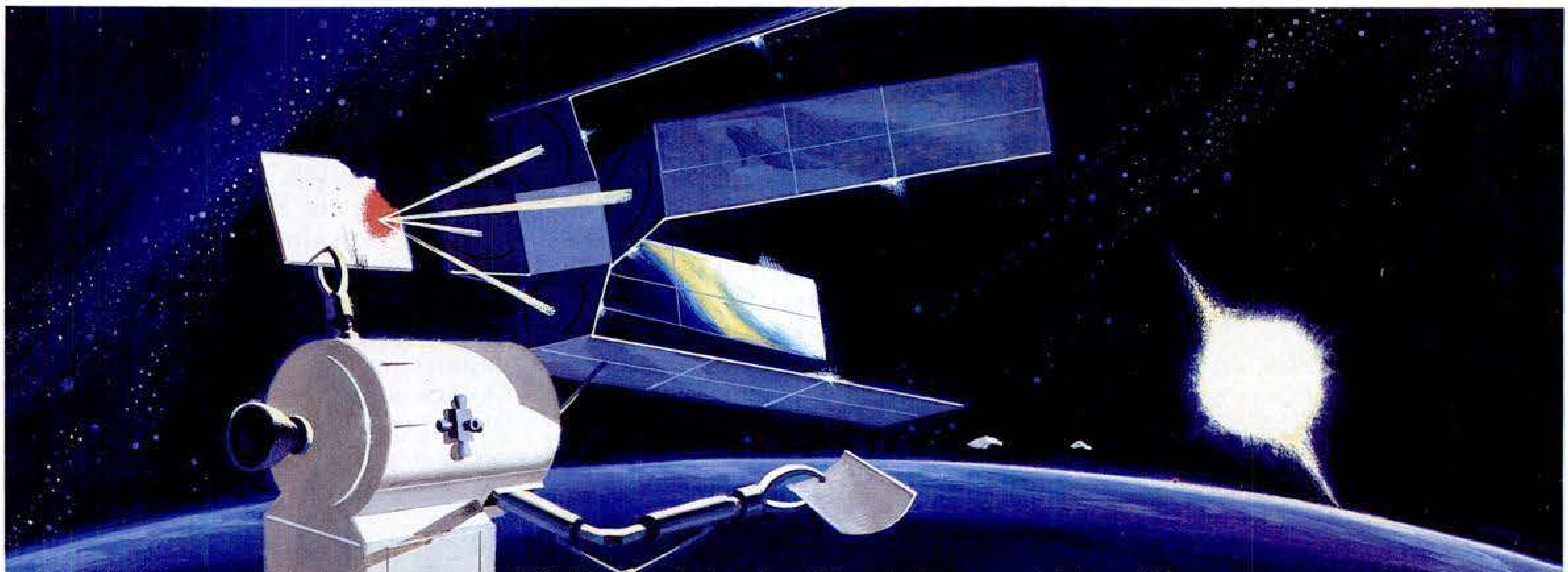
The year is 2008. NASA's space station Freedom has spent a decade in orbit without incident when an urgent message arrives from the ground. Missile-tracking radars at the U.S. Space Command have detected a two-inch piece of debris hurtling toward Freedom. The weight and composition of the fragment are unknown, but its speed is 15,000 mph, indicating it could strike with the force of a steel safe dropped from a 10th-story window. The fragment is approaching so fast that the station cannot be moved out of its way, and NASA has no choice but to exercise an option known as the "Safe Haven." Ground controllers order the astronauts to seek refuge in a specially fortified module—and prepare for the impact.

"The worst case," says Raymond Nieder, chairman of the meteoroid and debris working group at NASA's Johnson Space Center in Houston, "would be a piece of debris hitting a high-pressure storage tank." The tank might explode, venting its pressurized contents, which could also erupt, causing additional damage. An explosion, Nieder explains, might "sever the truss structure, and you'd have several large pieces of the space station floating around in orbit." The astronauts could repair minor damage, he says, but a major rupture would probably force them to remain sealed in their Safe Haven, awaiting rescue by the space shuttle.

After years of protecting astronauts and satellites from a variety of natural hazards, NASA now acknowledges that it must also shield itself from the residue of 30 years of human activity in space. More than 6.5 million pounds of man-made junk encircle our planet, cluttering what once seemed empty and infinite, and every bit of the flotsam is a menace—moving at orbital speeds as high as Mach 20. The same military radars that scan the skies for signs of a Soviet attack also track the largest and most hazardous chunks of space debris—some 7,200 items ranging from bobbled screwdrivers to defunct satellites. Just *one* could cause an accident comparable to the *Challenger* disaster, as a report to the National Security Council suggested in 1989. "Left unchecked," the report warned, "the growth of debris could substantially threaten the safe and reliable operation of manned and unmanned spacecraft in the next century."

In April of this year, a congressional agency accused NASA of under-

GARBAGE TRUCK OF THE FUTURE?



A robotic Autonomous Space Processor for Orbital Debris, designed by University of Arizona engineer Kumar Ramohalli and a corps of graduate students, would use radar and infrared "eyes" to locate debris. Pattern-recognition programming linked to a data base of known space garbage would then help the ASPOD identify the debris.

Using two robotic arms guided by a stereoscopic camera, the ASPOD—powered by small hydrazine engines—would grab a dead satellite, for example, and cut it apart by focusing sunlight through lenses into a 700-degree-C point. After adding usable pieces to its solar collector and stashing the rest, the ASPOD would move to another target, working from higher to lower orbits. Eventually, ground controllers would order the ASPOD to sacrifice itself and its gleanings in a controlled atmospheric burn-up or ocean splashdown. Ultimately, however, debris could become a resource to be recycled and used in space.

An ASPOD couldn't safely retrieve radioactive debris or satellites containing unspent fuel, Ramohalli cautions. And because many chunks of junk spin in orbit, an ASPOD might have to avoid half of the larger pieces of space garbage. Nor would it be able to collect the tiny flakes comprising 99 percent of space debris.

Ramohalli and sponsor Universities Space Research Associates hope to deploy a demonstration ASPOD by 1992. But technical monitor James D. Burke, at California Institute of Technology's Jet Propulsion Laboratory, says development typically takes five to seven years. Other NASA researchers are concentrating on debris prevention and don't expect to study removal methods for at least another decade.—*Mark Holman Turner*

estimating the potential danger to the space station Freedom. The General Accounting Office said contractors hired by NASA to design Freedom were relying on an outdated 1984 model of space debris. The accounting agency recommended that NASA reassess the debris threat before preparing the space station's final design requirements, due in July 1992.

Ingenious NASA engineers expect to prevent a cataclysm by designing and deploying spacecraft that are able to avoid or survive the orbital barrage. In recent missions, ground controllers have taken pains to maneuver spacecraft out of the trajectories of well-tracked pieces of debris. Eventually, NASA may also install onboard collision avoidance systems (see box, Headlights for Spacecraft). For the rest of the junk, NASA engineers are developing new materials and strategies to avoid the need to resort to the Safe Haven. Among the most promising ideas are stronger, lighter shields for spacecraft and satellites, including an unlikely armor—cloth.

Relatively simple shields may suffice, because NASA officials are most concerned about the tiny bits of space junk, all smaller than four inches, that comprise 99 percent of manmade litter. By one projection, 3.5 million particles—the legacy of hundreds of commercial, scientific, and military launches by the United States, the Soviet Union, and other nations—are suspended above Earth. These scraps are so plentiful that they may never be closely monitored.

"We've given up trying to track anything smaller than ten centimeters," says Donald J. Kessler, NASA's lead scientist for debris research at the Johnson Space Center. Like many NASA engineers, he observes that the odds of a serious collision with a large installation orbiting for decades are worse than those for short-hop vehicles like the space shuttle. "When you get something the size of a football field," says Kessler, "there is a good chance it will be hit."

The technical challenge of protecting spacecraft against debris of all sizes is so daunting that many scientists in academia virtually rule out defensive measures. "My feeling is that there is very little that can be done," says George B. Field, a professor of astronomy at Harvard. "These things are going at ten times the speed of a rifle bullet, and even a small piece causes great damage." Fred Lamb, a physicist at the University of Illinois and a Pentagon consultant, takes an even more pessimistic stance. A serious accident may be inevitable, he says. At orbital velocities, each particle of debris is "basically delivering four times its weight in TNT. If it goes through a vital part of a space structure, it will obviously devastate it. There will surely be fatalities."

NASA records already suggest the destructive potential of the smaller, uncataloged bits of space junk. In 1984 the Solar Max satellite was permanently disabled after thousands of collisions with what may have been nearly invisible pieces of rocket fuel or satellite fragments. Among the detritus that damaged the satellite, according to scientists who analyzed it later, were microscopic shards of human urine.

A year earlier, NASA had been forced to replace a $50,000 glass panel on the shuttle *Challenger* after a projectile traveling 8,000 mph left a pockmark in its windshield. The miniature missile turned out to be a fleck of paint, probably a byproduct of an explosion of the leftover fuel in a spent rocket stage.

With future collisions virtually assured, researchers are studying ways to minimize their effects. The most enduring contribution to the art of protecting spacecraft from debris belongs to Fred Whipple, the 83-year-old Smithsonian astronomer best known for his research on comets. As early as the 1930s, long before space flight, Whipple realized that a single-layer protective covering might be easily penetrated by just one tiny meteoroid. But he suspected that the extraordinary force of an impact could be spread over a large area by using *two* shields. The first would obliterate the particle, while the second would absorb the diffuse force of the shattered fragments.

Over the decades, as the dangers of man-made space litter grew more evident, NASA engineers began outfitting spacecraft with the double-layer system suggested by Whipple. The critical variables, they learned, are the thickness of each layer and the distance between layers. These are calculated and recalculated depending upon the size of the spacecraft and the particles it is expected to encounter.

While the Whipple bumper has never failed catastrophically, it does come with liabilities that have encouraged a new generation of NASA trouble-shooters to look for a better approach. The old system is extremely heavy: Such protection for just one of the space station modules might weigh in at 3,000 pounds. Besides the difficulty of hoisting so much aluminum into orbit, there is the sheer size of the thing: In effect, the space between the layers and the rigidity of the metal both require NASA engineers to shrink whatever they are trying to protect.

Even worse, the Whipple bumper exacerbates the problem it was intended to solve. With each violent impact, the shield sends a burst of aluminum fragments—bits of itself—into orbit. The Whipple bumper thus creates new debris every time it does its job. That troubles NASA, which has already forecast that the amount of man-made material will grow steadily in the years ahead, owing to greater human activity in space. "There's a lot more junk up there than the old model predicted," says Sherman L. Avans, the lead engineer with the Marshall Space Flight Center in Huntsville, Ala. "The Whipple bumper is not going to do the job in the new environment."

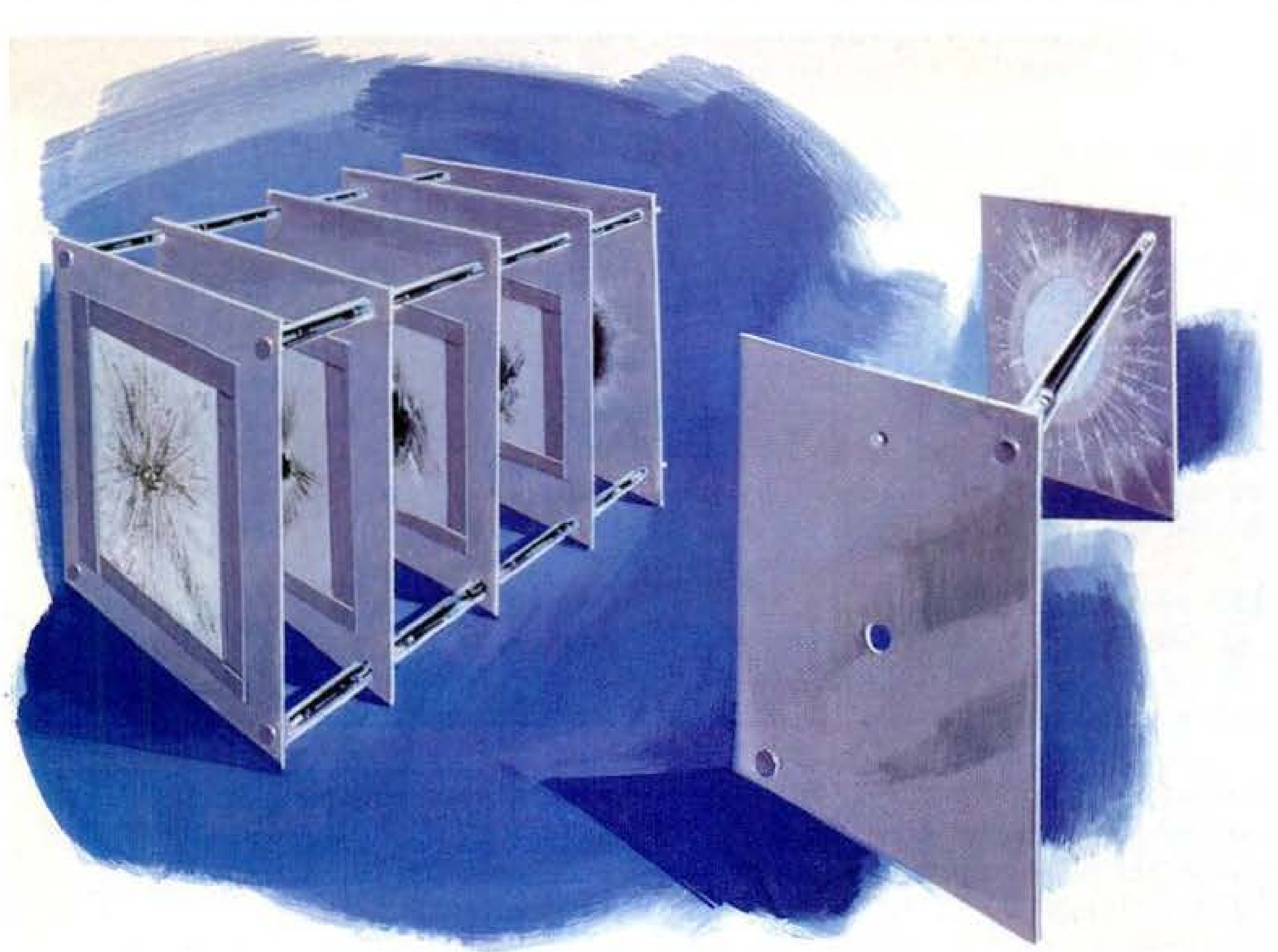
In its attempts to find a new system, NASA has tested modified Whipple bumpers made of graphite and Kevlar aramid fiber (the material used in bulletproof vests). At the moment, neither material seems to perform as well as aluminum, and both appear to eject bits of themselves when subjected to high-velocity impacts. NASA engineers have also proposed using baffles to deflect space debris, but such ploys would invariably weigh too much—and still contribute to the growing inventory of debris.

Five years ago a pair of engineers at the Johnson Space Center wondered if several *thin* layers of aluminum or another material might solve NASA's problems. Research physicist Burton G. Cour-Palais, a veteran of the battle against debris, had worked on the Apollo and Skylab missions; research engineer Jeanne Lee Crews had been testing a variety of new materials for NASA and the Department of Energy. Both were familiar with the high-velocity guns used to simulate particles orbiting at 15,000 mph. After years of experimenting, they settled on a shield consisting of four or five separate layers of a ceramic fabric called Nextel (see drawing). The tests now seem so promising that Cour-Palais and Crews have applied for patents on the design.

Their idea is simple. Unlike a thick aluminum bumper, which discharges a significant amount of metallic debris on impact, the thin layers of ceramic fabric administer a series of smaller shocks that produce fewer particles.

The final specifications of any multi-shock bumper will depend on a lengthy list of considerations, including the size and nature of the spacecraft, the duration and altitude of its mission, and the largest particle it is meant to block. In general, however, the layers of fabric seem flimsy, even diaphanous, considering the attack they must withstand. "They're so thin, you would intuitively say they're not going to work," Crews cheerfully admits. A multilayer shield designed to absorb particles 1/8 inch long "is probably the thickness of a wool sweater," says Crews, the manager of the hypervelocity impact research laboratory at the Johnson Space Center. "That's one sheet. You'd have to use four of those." Those four "sweaters" could prove far easier to transport than a Whipple shield: The cloth might be rolled or folded during the launch, leaving more room for cargo.

NASA managers, for their part, express admiration for the cleverness of the multi-shock scheme, but expect that it will require additional testing before being formally adopted for Freedom or anything else. "It sounds like a good idea, and it looks like a good idea," says Avans, at the Marshall Space Flight Center, "but I don't want to commit to it until we have a chance to evaluate it." One way to minimize doubts about the new scheme may be to fuse it with the old, covering a traditional Whipple bumper with ceramic fabric. That combination might offer all the dependability of aluminum and the environmental advantages of cloth.



The two-layer aluminum Whipple shield (right) prevents damage to spacecraft, but creates additional debris by shattering projectiles. A multi-shock bumper made from ceramic fabric (left) shatters the projectile in stages, releasing less debris. "A solid aluminum projectile ends up being totally melted," says Jeanne Lee Crews of the Johnson Space Center. "It's almost as if you could take melted butter and splatter it on a skillet, and it would stay there."

None of the proposed shields, even the most impressive, will be constructed to survive collisions with fragments more than an inch long. The U.S. Space Command—a military agency—generally doesn't track pieces smaller than four inches, so NASA is experimenting with radar systems capable of detecting the intermediate-size particles that could devastate a shielded spacecraft.

During a recent evaluation of sophisticated radars in Goldstone, Calif., and Arecibo, Puerto Rico, NASA surveyed the sky for debris between ½ inch and four inches in size. "The U.S. Space Command has long contended that they're complete down to one centimeter," says Kessler of the Johnson Space Center. "We're not there yet." He explains that NASA expected to find about 50 small fragments during the test, but in fact located 100. Another study, using a telescope at MIT's Lincoln Laboratories, discovered five times as much orbital debris as had been previously identified in one range of altitudes. "It worries us a little," Kessler says. "Undoubtedly they [the U.S. Space Command] are close to the limit of their capability."

In all, according to the National Security Council report on space debris, there may be as many as 17,500 intermediate-size pieces—more than twice the number of items now tracked by the military. The upshot may be that NASA will have to reassess its ability to anticipate danger and maneuver large, manned spacecraft out of the way.

The main technical hurdle to tracking smaller debris, oddly, does not lie in improving the electronic capacity to see a blizzard of tiny orbiting objects. Richard Goldstein, a radar astronomer at the Jet Propulsion Laboratory, has studied space detritus using NASA's Goldstone radar—an installation that, he says, is the most sensitive in the world. "With that radar," he says, "you can see amazingly tiny things—two millimeters and better at 600 kilometers [373 miles] altitude."

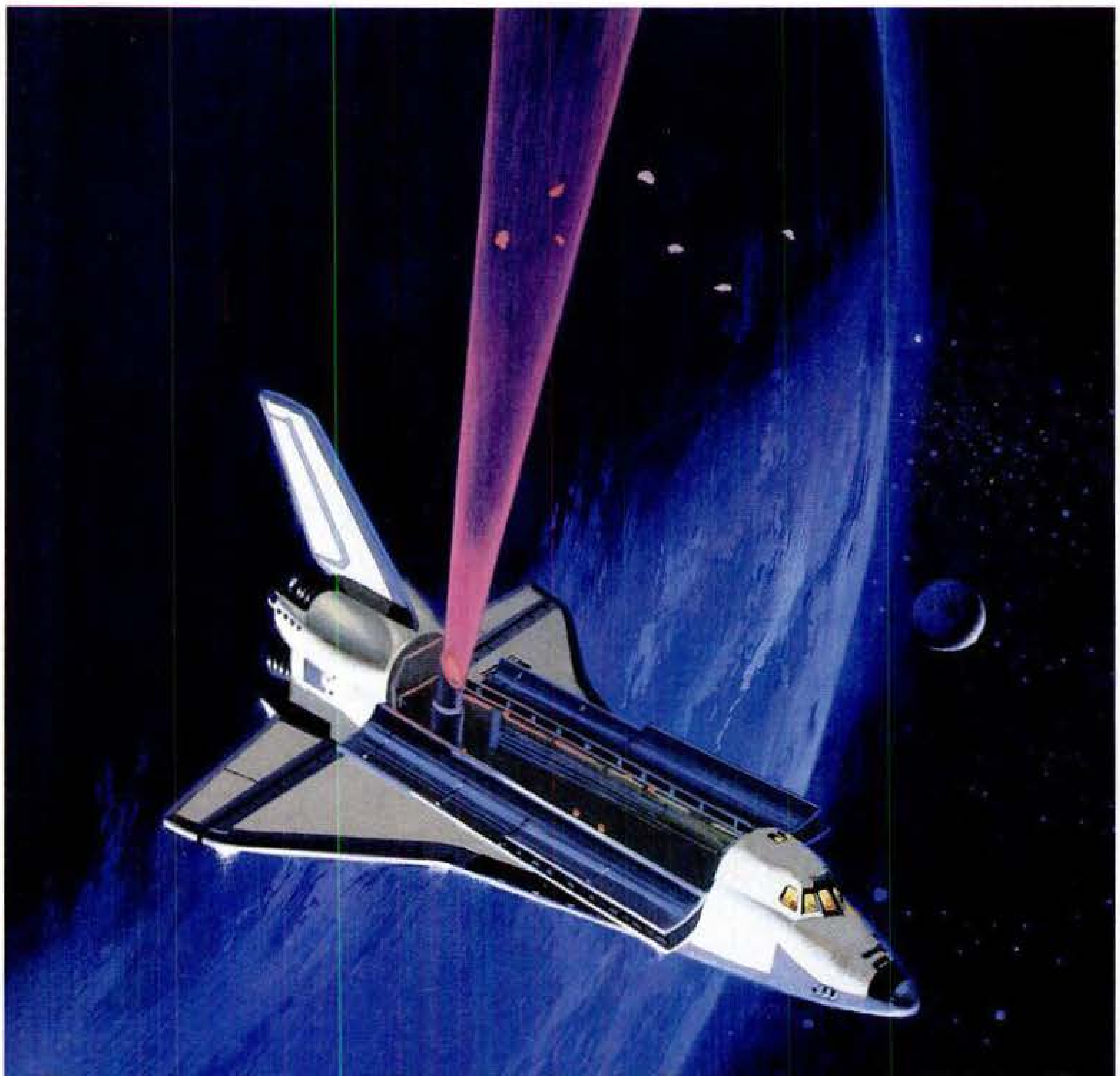
What eludes NASA and the Pentagon, rather, is the ability to remember and *predict* the location of thousands of pieces of debris. When a steel bolt cast off by a satellite hurtles through radar—in much the way that a moth flits through the beam of a flashlight—it may be clearly visible, but only for a fraction of a second. Even military experts have no way to know whether the orbiting bolt is new or previously identified.

"The limitation is not in the antennae and the sensors, or the power that we can generate and throw out of the radars," says Col. Gary Payton, a former shuttle astronaut who is now working in the technology office of the Strategic Defense Initiative (the Star Wars program). "The limitation is in our computational ability to filter and track and correlate. It takes sophisticated software to do that. You have this computational problem of determining which piece of junk is going in which direction and crossing the path of another going in a different direction. The radar is inundated."

The military and NASA hope to cooperate in writing computer programs for the Haystack radar, part of Lincoln Laboratories. The new programs will sift the millions of bits of data from the radars to predict accurately, among other things, whether a particular chunk of aluminum is about to make an unscheduled rendezvous with the Hubble Space Telescope. However, Payton says the project may take years to finish.

[Continued on page 92]

HEADLIGHTS FOR SPACECRAFT



The maelstrom of space debris is less intimidating to NASA engineers who think about the junk on a piece-by-piece basis. Faith Vilas, an astronomer and Johnson Space Center space scientist, envisions a collision warning system that could alert ground controllers to a single piece of material coming directly toward the space station. To prove that debris could be detected, Vilas has designed an experimental system to be carried aboard a space shuttle (above).

Borrowing on her knowledge of telescopes, and on the theory that an orbiting object such as a wrench would reflect light and radiate heat, Vilas hopes to test sophisticated sensors that would be mounted on the space station and, like high-tech headlights, pointed toward oncoming debris. In space, Vilas suspects, infrared radiation may prove more useful than light. (The floating wrench may emit heat even when it is shaded from the sun by Earth.) And because orbiting sensors would not be scanning the entire sky for millions of pieces of junk, they could focus on whatever actually posed a threat to a particular spacecraft. A wrench destined for a head-on collision with the space station Freedom would appear almost stationary, just as the most ominous beacon to a ship's captain is one that *doesn't* move and just gets brighter. "The boat that's coming straight at you," Vilas explains, "is the one that doesn't appear to be moving with respect to the background."

If the sensors detected a chunk of debris that seemed motionless, space-based radars—also scanning a small portion of all the debris—could confirm its trajectory and assess the peril to the spacecraft. Under the best conditions, Vilas says, such a detection system might give astronauts just two minutes to prepare for a collision. But even that brief interval could allow them to take refuge in the Safe Haven.—*M. D. U.*

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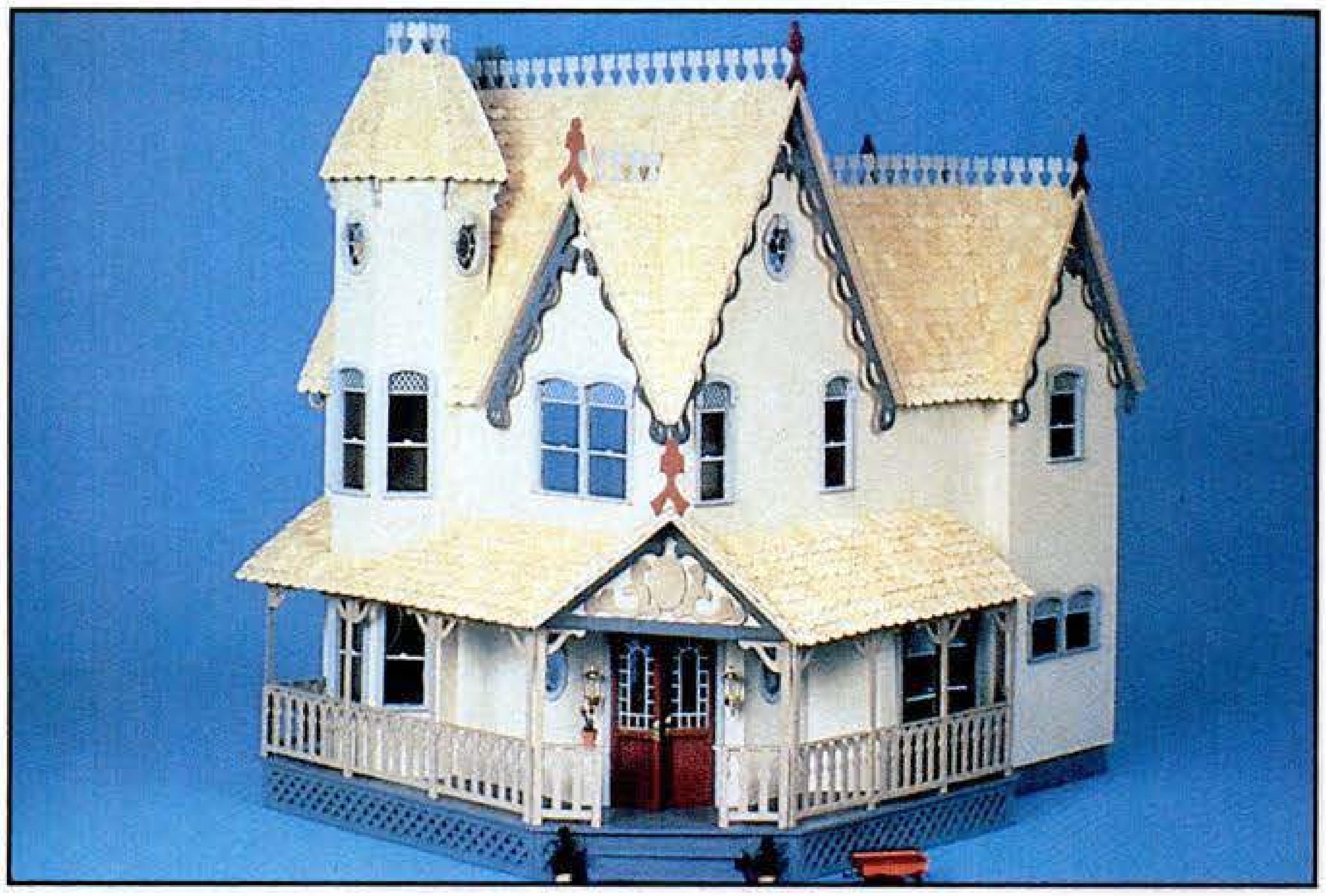
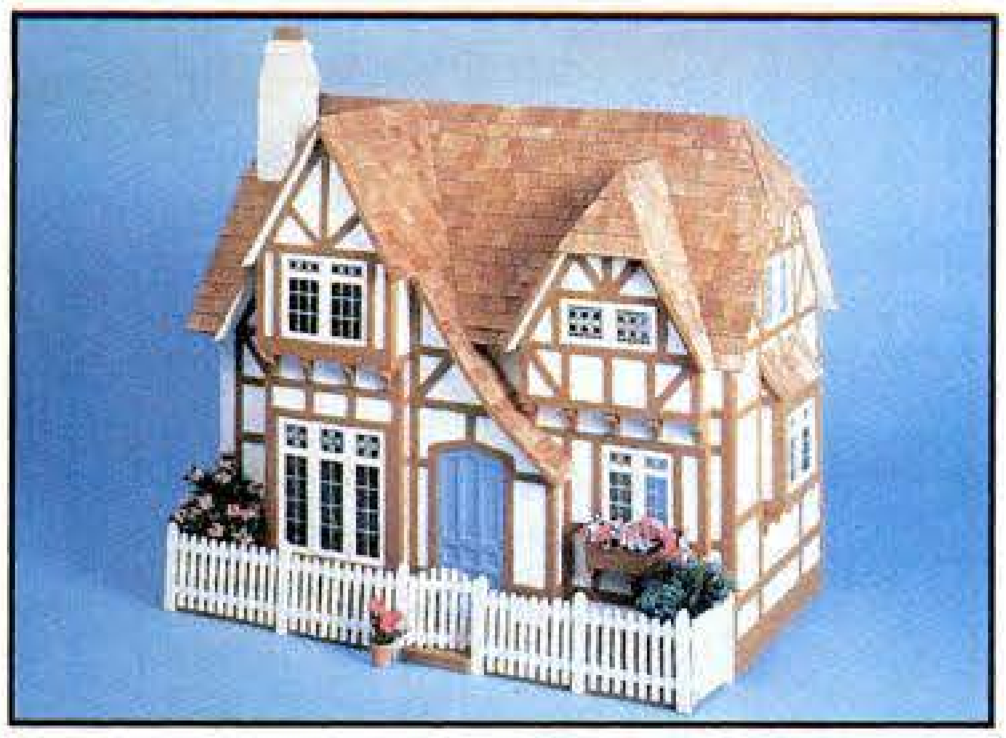


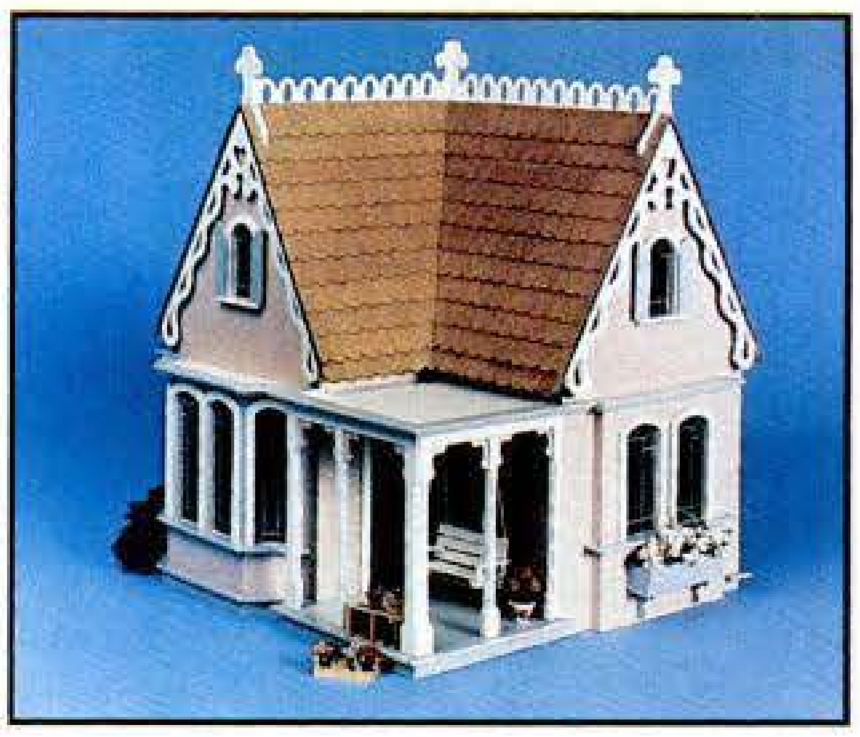
The Pierce

Victorian charm abounds in this six room dollhouse. In addition to the wrap around veranda and tower, this house features two fireplaces, an attic, an elegant curved staircase and a secret tower chamber. Set up size is 35½″W × 25″D × 33″H. $95.00 plus $5.00 shipping and handling.



The Glencroft

This Cozy Tudor cottage includes a picket fence and window box. Inside there are four rooms, a winding staircase, built-in bookcases, two fireplaces and two window seats. Set up size is 24″W × 17″D × 21″H. $66.00 plus $4.00 shipping and handling.



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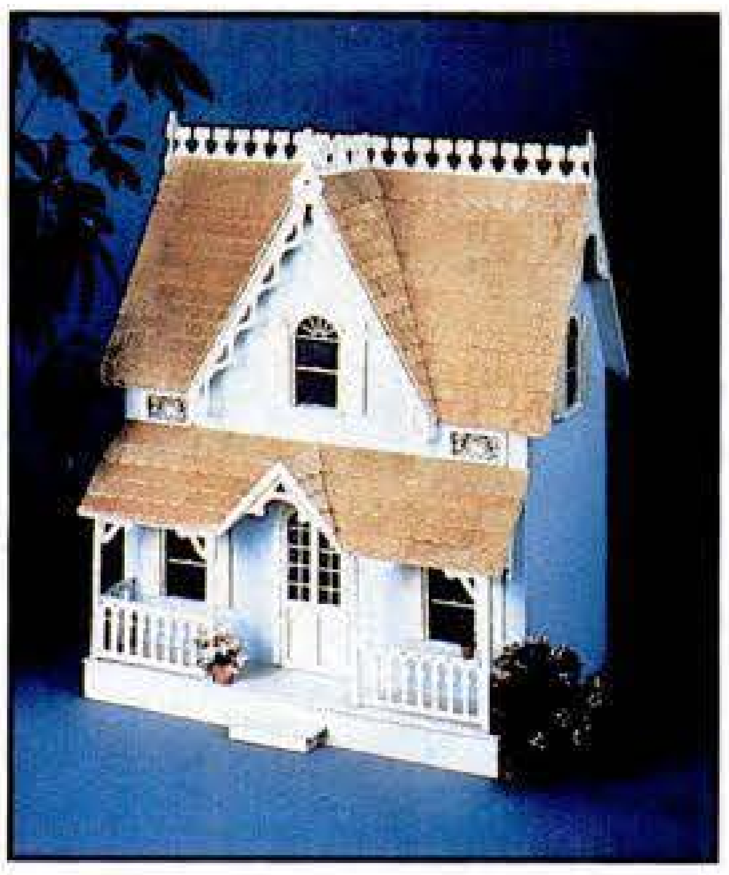
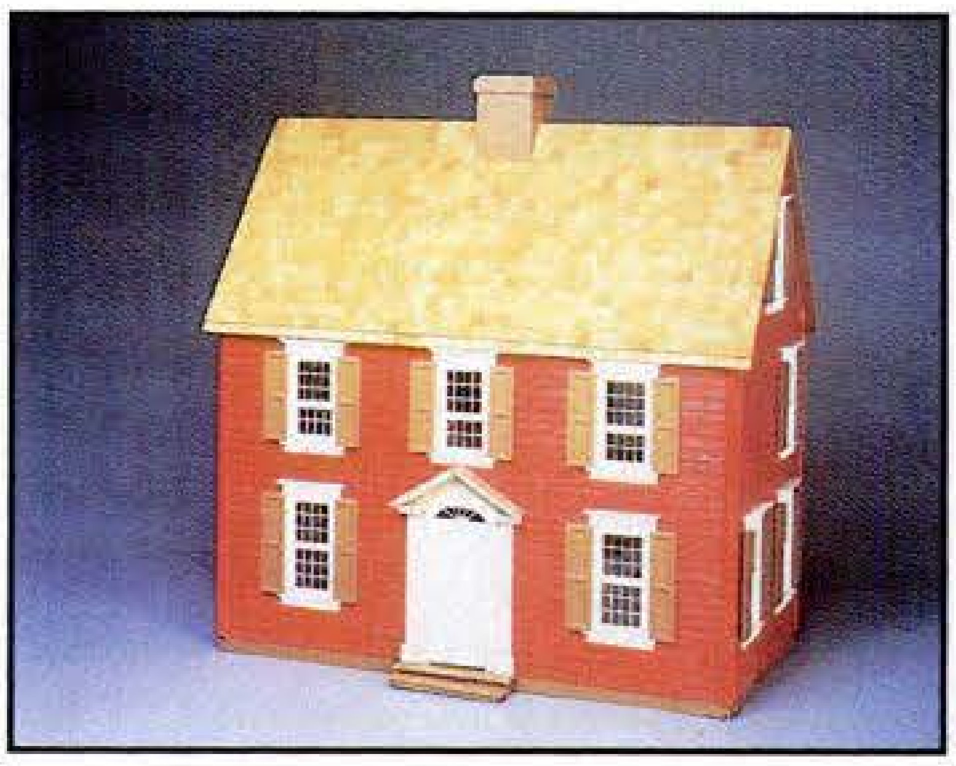


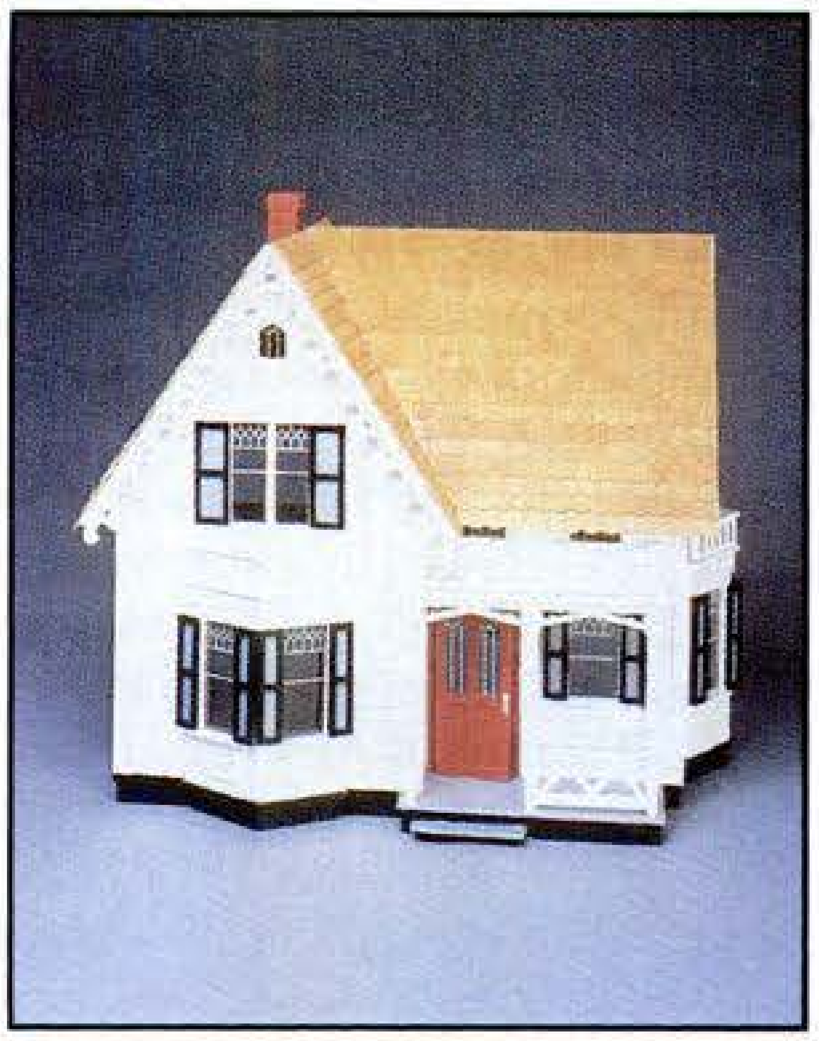
The Arthur

This four room cottage is enhanced by a quaint front porch and gingerbread on the ridge and roof. It makes an ideal house for the new collector. Set up size is 18″W × 13″D × 23½″H. $34.00 plus $4.00 shipping and handling.



The Jefferson

This traditional colonial dollhouse features a paneled front door, a built-in bookcase wall with a fireplace in the living room and a center hall with staircase. This is truly an authentic dollhouse. Set up size is 28″W × 16″D × 29″H. $73.00 plus $4.00 shipping and handling.



The Westville

Carpenter Gothic is the style of this turn of the century house. There are four rooms plus a spacious attic. Elaborate trim adorns the porch, balconies and the roof. Other features include a central staircase and two bay windows. Set up size is 25″W × 18½″D × 22″H. $65.00 plus $4.00 shipping and handling.

CARY HENRIE

FUZZY LOGIC

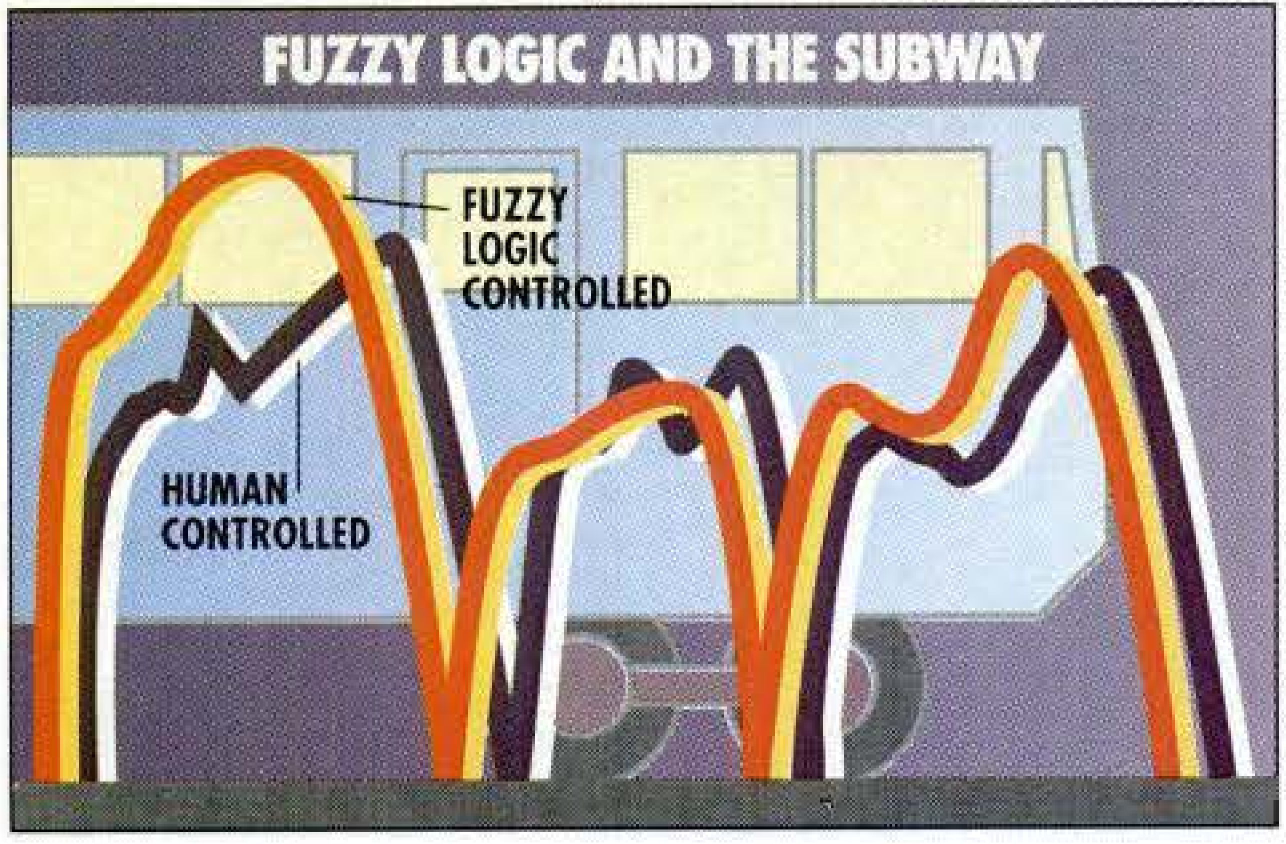
"Fuzzy" subways, air conditioners, and automatic transmissions operate more efficiently and smoothly than their conventional counterparts. Why? Fuzzy logic enables computers to simulate the ambiguities encountered in real-life situations.

By J. T. JOHNSON

A well-dressed man sits in a Japanese subway car, balancing a half-filled aquarium on his knees. As the train leaves the station and picks up speed, the water gently pushes toward the rear end of the tank. When the train reaches cruising speed, the water levels out. As the subway brakes for the next stop, the water level rises on the forward end of the aquarium, but again evenly and gradually. No splashes, no spills. Why not? Because the train is regulated by a once-obscure branch of mathematics applied to computer controls.

While this type of math evolved in the United States, practical applications for it are mushrooming in Japan. Soon you'll see TVs, camcorders (see box), and cameras employing new electronic circuits that promise enhanced images. Japanese washing machines, elevators, and anti-lock brake systems benefit from improved computer performance. Researchers are aiming for speech-recognition and robotic "eye-brain" applications. In this country, the government is using the mathematics to help model political shifts in Eastern Europe.

This division of mathematics, called fuzzy logic, is now applied to helping computers simulate the vagueness and uncertainty inherent in our thought processes and language. Computers normally solve problems by breaking them down into a series of yes-or-no decisions, represented by ones and zeros. But fuzzy logic lets computers assign numerical values that fall somewhere between zero and one. Instead of statements or conditions being only true or false, no maybe's or sort of's, fuzzy theory sets up conditions such as slow, medium,



A fuzzy system that controls acceleration and braking in Japan's Sendai subway provides a smoother ride than would human drivers.

and fast. And because it doesn't require all-or-nothing choices, and represents real-world events as continuous phenomena, fuzzy logic seems to make a variety of computer-controlled machines run more smoothly and efficiently. The Sendai subway system in Japan, for example, accelerates and brakes more evenly than a human driver (see graph). Passengers don't even bother hanging onto straps.

An American, Professor Lotfi A. Zadeh of the University of California at Berkeley, developed fuzzy-logic theory 25 years ago. "I gave quite a bit of thought to what to call it," said Zadeh. "I realized that fuzzy didn't sound good. But at the same time, I could not find a scientific term that described it as accurately as fuzzy did."

What sounds whimsical in English is taken seriously in Japan, where fuzzy logic is *fuaji riron*. *Fuaji* has no meaning in Japanese—it's the word fuzzy rendered in the closest Japanese pronunciation. *Riron* is usually translated as *theory*.

Japanese society has taken to fuzzy the way Americans took to turbo. More than 50 Japanese companies are developing fuzzy applications and chips, and two multi-million-dollar consortia backed by the biggest corporations in Japanese technology have been formed there to further the research.

One of the first fuzzy products on the market was an air conditioner made by Mitsubishi Heavy Industries. Non-fuzzy machines tend to alternate between two states: on and off. Air conditioners, for example, turn on when a room is too hot, and shut off when it's too cold. But a fuzzy air conditioner slows down gradually as a room cools to the desired temperature: That means energy savings of up to 20 percent.

A sister company, Mitsubishi Electric Corp., is using fuzzy control systems in its elevators, cutting average waiting time by 15 to 20 percent.

Hitachi Ltd. and Matsushita Electric Industrial Co. recently introduced fuzzy washing machines that sample laundry water to determine how dirty your clothes are and then select the optimum detergent and washing method. Washing time is based on weight and degree of contamination. Matsushita has also designed a fuzzy shower system that detects changes in temperature and adjusts flow, preventing scaldings.

Marketers may have a tough time explaining the merits of TVs with fuzzy pictures, but machines will be available this summer. Sony recently unveiled two models, priced at $1,450 and $2,700, that use fuzzy circuitry to make subjective decisions about sharpness, brightness, and color.

Meanwhile, Japanese automobile companies are pushing hard to incorporate fuzzy logic technology in their vehicles. Subaru is developing an electronic continuously variable transmission that might be in cars by the next model year. Nissan has patented fuzzy automatic transmissions and anti-lock brake systems.

Fuzzy controls are also being used to run an aluminum-cutting machine, a trench-digging machine, and a machine used to diagnose thyroid cancer. Yamaichi Securities uses a fuzzy-based stock market analysis system that has reportedly generated a yield above 50 percent for the past three years.

Fuzzy's lack of acceptance among Western researchers is attributed to their thirst for precision in all things scientific. Oriental cultures, it's argued, are more accustomed to holistic thinking—"dawn" has the same importance as "night" or "day." Contemporary Western thought, on the other hand, is biased toward either-or logic.

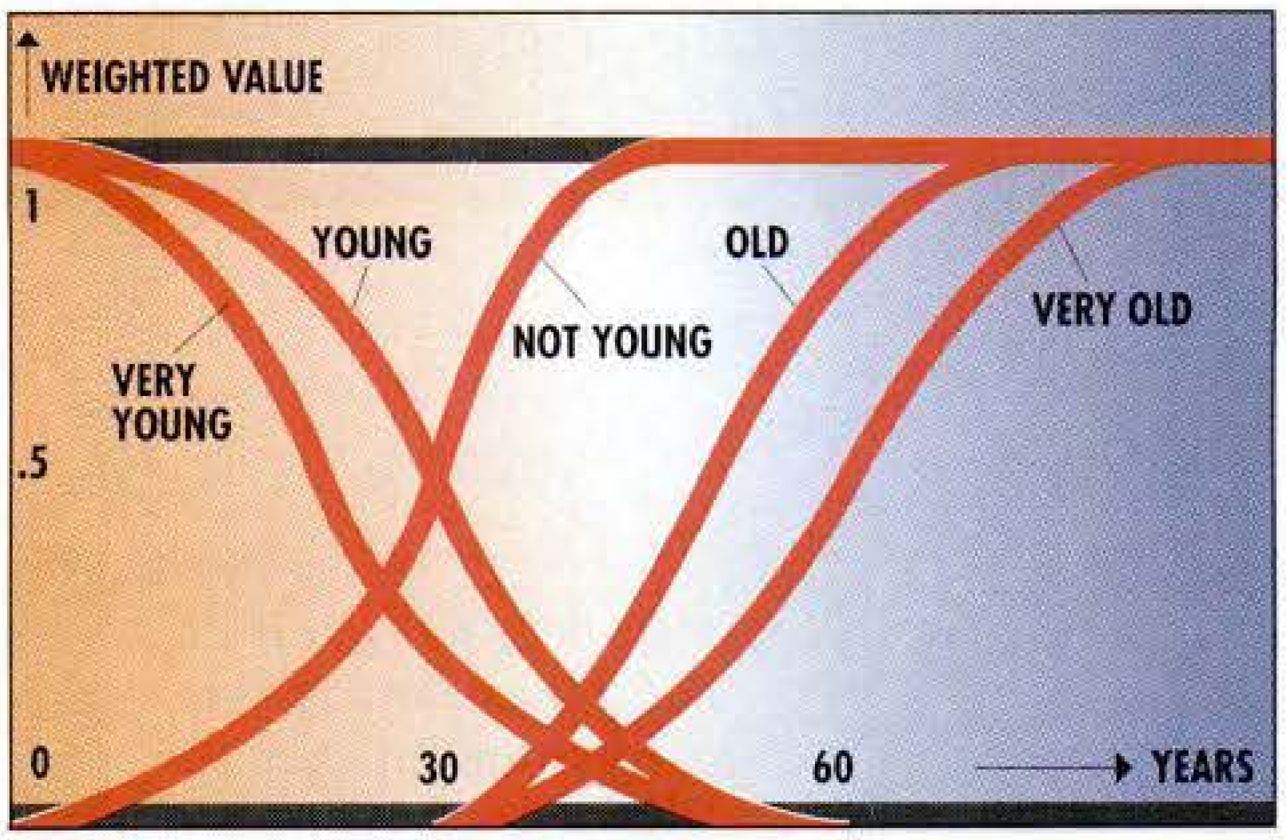
Only one or two U.S. companies and NASA have taken a serious interest in fuzzy systems. NASA is experimenting with fuzzy controls that could help the shuttle dock at the space station. A pilot could fly the approach manually, but not without a plethora of correcting movements on the joy stick, a computer simulation shows. The simulation predicts that a fuzzy-logic autopilot computer would bring the spacecraft to its rendezvous with the grace of a Bolshoi ballerina and minimum fuel burn.

Togai InfraLogic of Irvine, Calif., is the only North American company producing a fuzzy-logic computer-chip set. Using this graphics and language software, programmers can write fuzzy rules for control or analysis systems. A Togai-designed system is used in Mitsubishi's air conditioner and other products.

Carl Perkins, vice president of business development at Togai, says most Westerners are biased toward binary logic and its "balls and urns": "People can understand how to predict if the next ball pulled out of an urn will be black or white. But if you put balls with any shade of gray in an urn, the binary bias makes you throw up your hands and say, 'It's impossible to predict.' But it's not."

The champions of fuzzy logic see the introduction of quantum mechanics, with its inherent ambiguities, as the first wave of fuzzy logic's evolution. The second wave came in 1965, when Zadeh published a paper on "fuzzy sets," as he called them. Zadeh wrote that a set of speed measurements grouped around a point on a zero-to-one continuum, for example, could be lumped together and called slow. Eliminating the need for precise measurements would simplify computations, Zadeh theorized.

Twenty years later, Bart Kosko happened upon Zadeh's paper. Kosko, who had studied music, philosophy,



Fuzzy-logic programmers use membership function graphs to represent value-laden descriptions such as "middle-aged." Here, the programmer defines youth as the years between birth and age 50. Years within that range are assigned values reflecting how close they are to the age that "experts believe" is the most youthful. Year two might have a weight of 0.99, because virtually everyone agrees a two-year-old is young, while year 40 might have a weight of 0.2. Middle age is where youth and old age intersect; graphs like this one can help answer questions containing elements of uncertainty: Is Bob middle-aged? Should he have an electrocardiogram?

and economics before receiving a master's degree in applied mathematics, became intrigued with fuzzy logic. He eventually earned his doctorate in electrical engineering by challenging the foundations of probability theory—a set of assumptions evolved from techniques that the wealthy had used to calculate the odds at dice tables in the 16th and 17th centuries.

"I was convinced fuzziness existed, and I set out in my dissertation to prove its existence one way or another—and, if it did exist, to characterize it mathematically," the 30-year-old scholar, now an assistant professor of electrical engineering at the University of Southern California, said.

What he found, Kosko says, is the third wave of fuzzy theory. "Fuzziness begins where Western logic ends," he said. Consider the collection of molecules we call a table. If we could dismantle it one molecule at a time, at what point would it cease to be a table and become a few stray molecules? Questions like this aren't a problem for fuzzy logic, which bases decisions on generalizations rather than exact measurements.

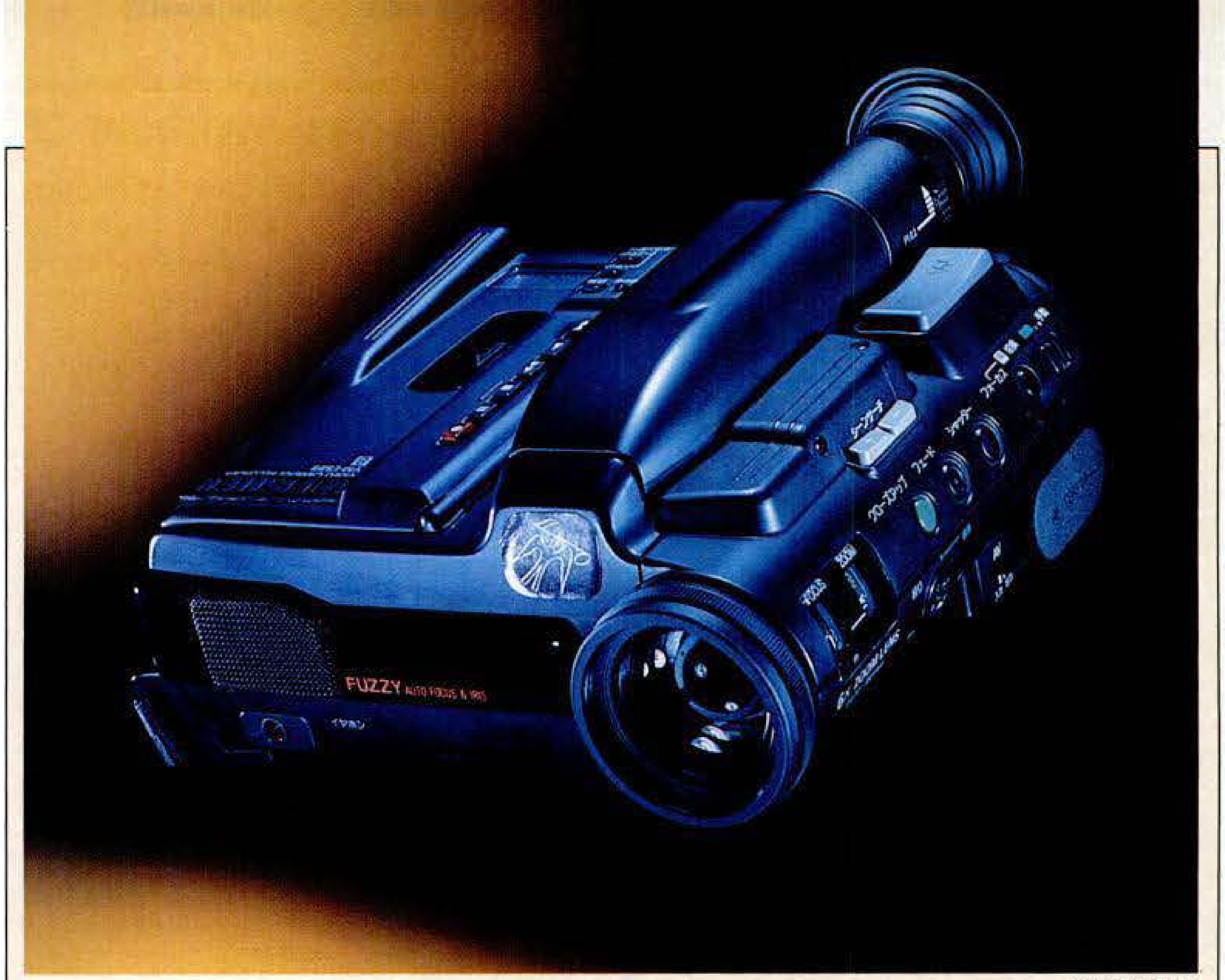
Kosko and his peers are moving into areas staked out by artificial intelligence researchers in the past 30-plus years, and the move is not always understood or welcome. Artificial intelligence is a subdivision of computer science devoted to creating programs that imitate the human mind. Much of what humans think and do is instinctively based on probability, but probability-based systems demand a high degree of mathematical precision and require hundreds of rules.

"Rounding off simplifies life and often costs little," said Kosko. "We agree, as social animals, to call the near-empty cup empty." A fuzzy system can define everything from one drop to two ounces as empty and use that definition to trigger some action, like deciding to put the cup in the dishwasher.

The exciting thing about fuzzy logic is that it appears to have such broad applicability that future uses are likely to be surprises. Researchers talk glibly about employing it to recognize natural speech—in which two speakers never pronounce a word exactly the same way—or to help a robot identify obstacles on a factory floor. Such applications are not what Zadeh anticipated 25 years ago.

"My expectation was that applications would be primarily in systems in which human judgment and emotions play a certain role," said Zadeh, "and in which you do not have, or did not have, a collection of quantitative techniques." He expected fuzzy logic to be used in law and psychology, not washing machines.

Social-science applications may come. A political scientist who is a consultant for the U.S. State Department is already using a fuzzy model to study the rapidly changing situation in Eastern Europe. The model allows her to assign weights to anecdotal news reports and phone conversations with European contacts. The political climate is changing so quickly that precise data are not available. Ironically, fuzzy logic—the theory that is so difficult for Western scientists to accept—seems to be the only one that can predict how the upheaval in the Eastern bloc will affect the West. PS



JOHN B. CARNETT

FUZZY PICTURES

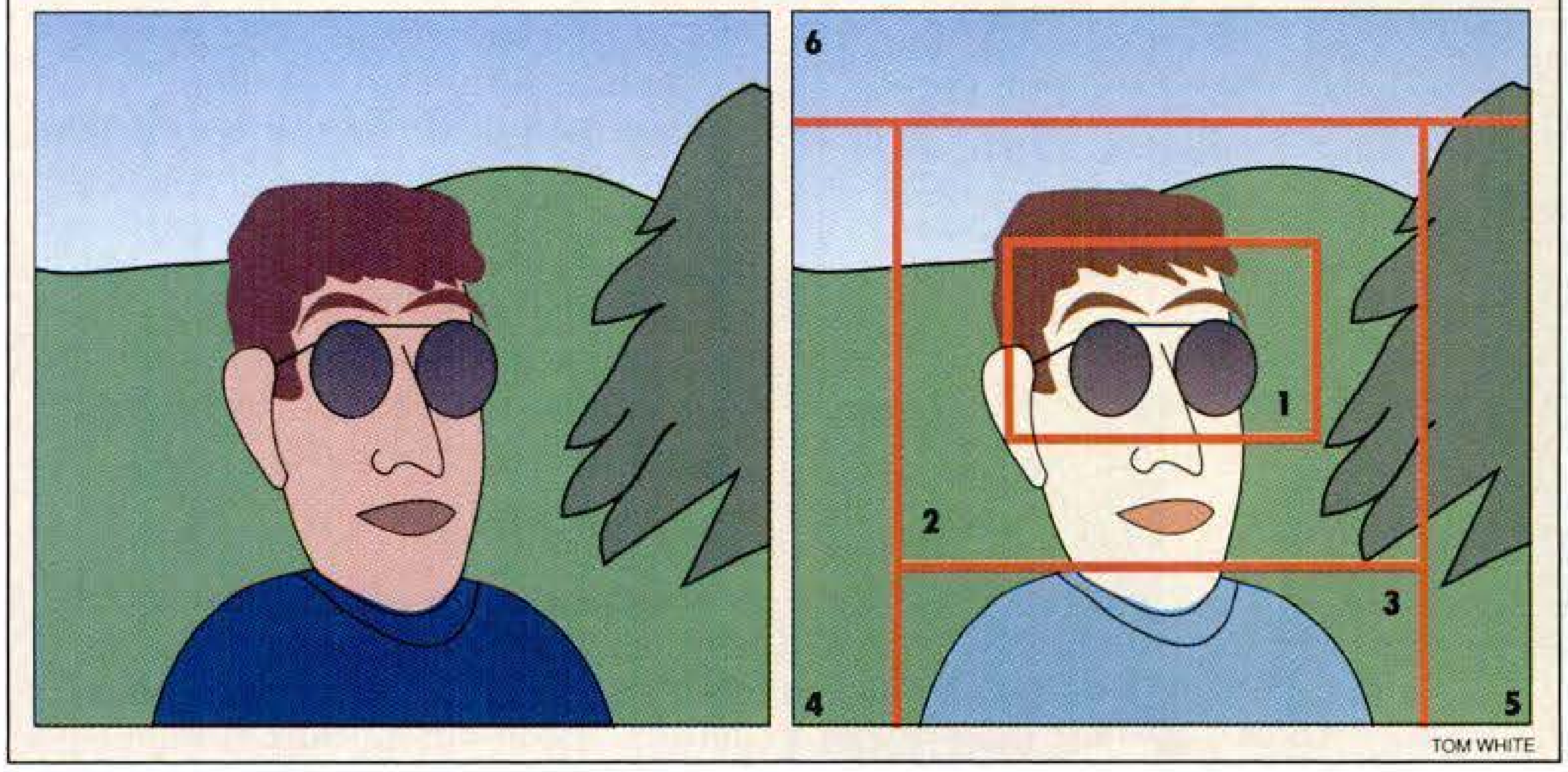
Sanyo Fisher's 8mm video camcorder, the FVC-880 (top), uses fuzzy logic circuitry to evaluate focus and lighting conditions.

Backlighted subjects have long fooled automatic light meters. In older cameras that had automatic apertures, an average light reading was taken from the entire scene. If lighted from behind, the subject would be underexposed (below left).

To correct this, later cameras divided the viewing area and took a weighted average of the light readings, giving sectors in the middle of the frame more importance in determining the aperture setting. In Sanyo's earliest camcorders, the frame was divided into six sectors. In averaging the readings, sector one got the most weight; sector six, the least.

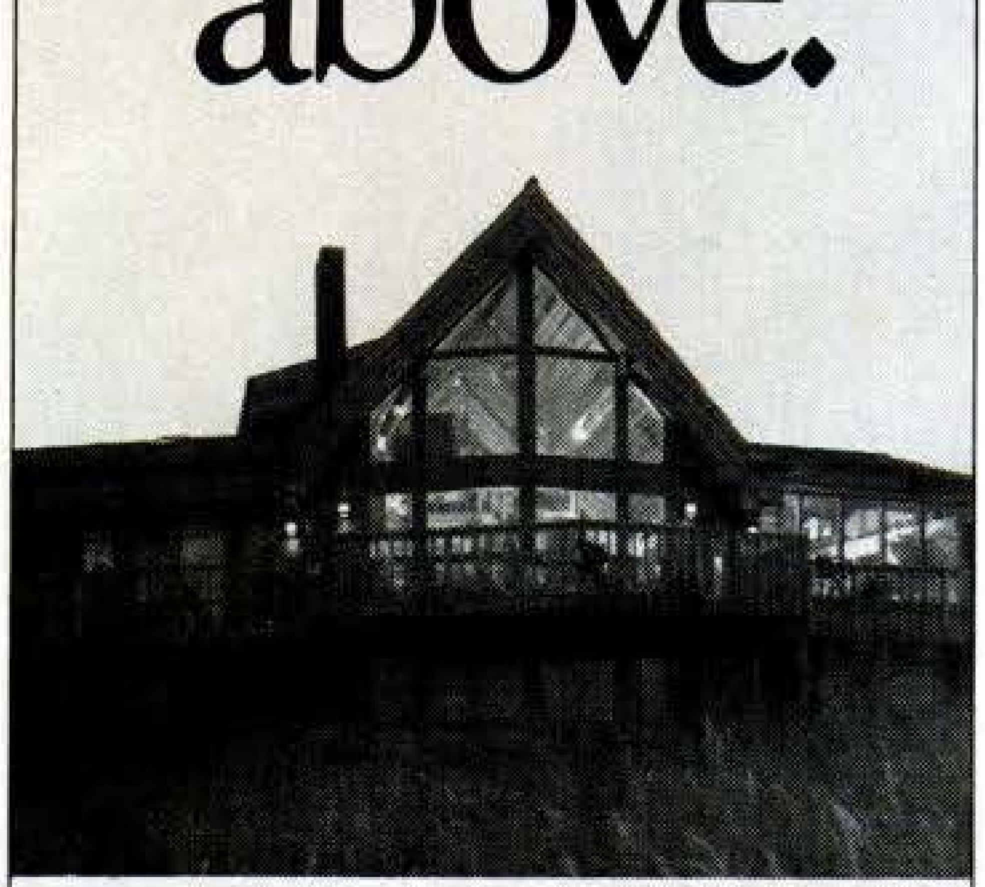
The fuzzy system uses the same six sectors (below right). But now the machine makes value judgments about the scene. If the light readings of sectors one and three are "roughly equal," and sector two is "much brighter" than sector one, then sectors one and three are given priority in the light reading calculation. How much priority will depend on the contrast between the sectors. If the brightness of sectors one, two, and three are all "roughly equal," none gets priority.

Sanyo's system uses nine rules to set the diaphragm opening. Because the fuzzy values change gradually, the system produces smooth transitions between different lighting conditions.—*Dennis Normile*



TOM WHITE

A cut above.



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Refrigerators—without CFCs

[Continued from page 63]

The Association of Home Appliance Manufacturers, the EPA, and the Department of Energy have organized a research consortium to seek alternatives to CFCs. In the short term that means finding a chemical similar to CFC-12 that can be used in a standard refrigerator. The early favorite was HFC-134a; Allied-Signal, Du Pont, and ICI have already begun making it. But with comparable equipment, HFC-134a is at least five percent less efficient than CFC-12, and incompatible with some of the lubricants used in refrigerators.

EPA specialists are also interested in a chemical called HFC-152a, which has been commercially available in blends for 20 years. It's more energy efficient than CFC-12, it has an ozone-depletion potential of zero, and it has low greenhouse-warming potential. Sounds perfect. There's just one problem: It's moderately flammable. Because of product liability concerns, manufacturers are wary of HFC-152a. But its other characteristics are so desirable that the EPA is encouraging laboratories to study the flammability problem.

"It is possible to restructure the flammability requirements," said Don P. Grob of Underwriters Laboratories at a December 1989 symposium sponsored by the EPA. "Changes in appliance design, limitations on refrigerant quantities, and restrictions on arcing parts...may address flammability concerns equally as well as requiring a nonflammable refrigerant." Grob also proposed adding an odor trace gas—like the one used to warn of natural gas leaks—to refrigerants.

Chemical substitutes alone won't enable manufacturers to stay ahead of efficiency standards. Manufacturers are also investigating design changes. One promising approach is to split the vapor compression cycle into two separate loops—one for the freezer and one for the cooling compartment (see drawings).

Tiny buildings

In addition to alternative refrigeration methods, insulation is considered vital. Think of a refrigerator as a small, inside-out building, suggests David Goldstein, a senior scientist at the Natural Resources Defense Council (NRDC). Relative to the kitchen's room temperature, he says, "It's in a climate colder than anywhere in the United States." To match the cost-effectiveness of a typical building's attic insulation, a freezer's sidewalls would require insulation with a value of R-60; today's refrigerator insulation has an actual value of R-12.

The NRDC is helping Thermalux, a Richmond, Calif., company, build a prototype refrigerator insulated with evacuated aerogel panels. Aerogels, microporous silica gels that are up to 97 percent air, previously have been used to insulate windows ["Amazing Glazing," Aug. '88].

Powder-packed panels

Silica powders are the filler for evacuated panels tested by Oak Ridge National Laboratory and General Electric a few years ago. GE developed its panels to meet California's tough energy standards, but has never mass-produced them. The company questioned whether the edge seals of its panels could maintain a vacuum for the 19-year life of a typical refrigerator. However, at least one company is already putting silica powder insulation in products such as the steel buckets fishermen use to keep their prey alive. MBB, a West German aerospace company, makes the silica superinsulator from diatomaceous earth.

Meanwhile, the Solar Energy Research Institute (SERI) has developed a "high-vacuum" insulation. Whereas powder- and aerogel-filled panels, which have plastic shells, require only a "low" vacuum, SERI's panel is more like a thermos bottle, and requires a high vacuum. It consists of two sheets of stainless steel welded together by a laser beam. Glass beads or embossed glass sheets act as spacers inside the metal envelope. Early design prototypes of SERI's panels are now being tested at Admiral and Whirlpool, says Dave K. Benson, co-inventor of the insulation.

Cryogenic research may also yield new insulating materials for home refrigerators. One candidate is Cryotherm, flat sheets of microfiberglass superinsulation manufactured by Lydall Manning Nonwovens of Troy, N.Y.

With better insulation, novel refrigerator designs might be feasible. Field studies have shown that the number of times you open a refrigerator's door has little effect on its total energy consumption. So if its walls were superinsulated, a refrigerator could operate on low power.

"We would like to see the electricity that refrigerators use reduced fifty or sixty percent from even the 1993 standards," says John S. Hoffman, director of the EPA's Global Change Division. Forcing manufacturers to eliminate CFCs will ultimately help customers save money on their energy bills, he says. "We see a great opportunity for consumers to benefit from this transition."—*Dawn Stover*

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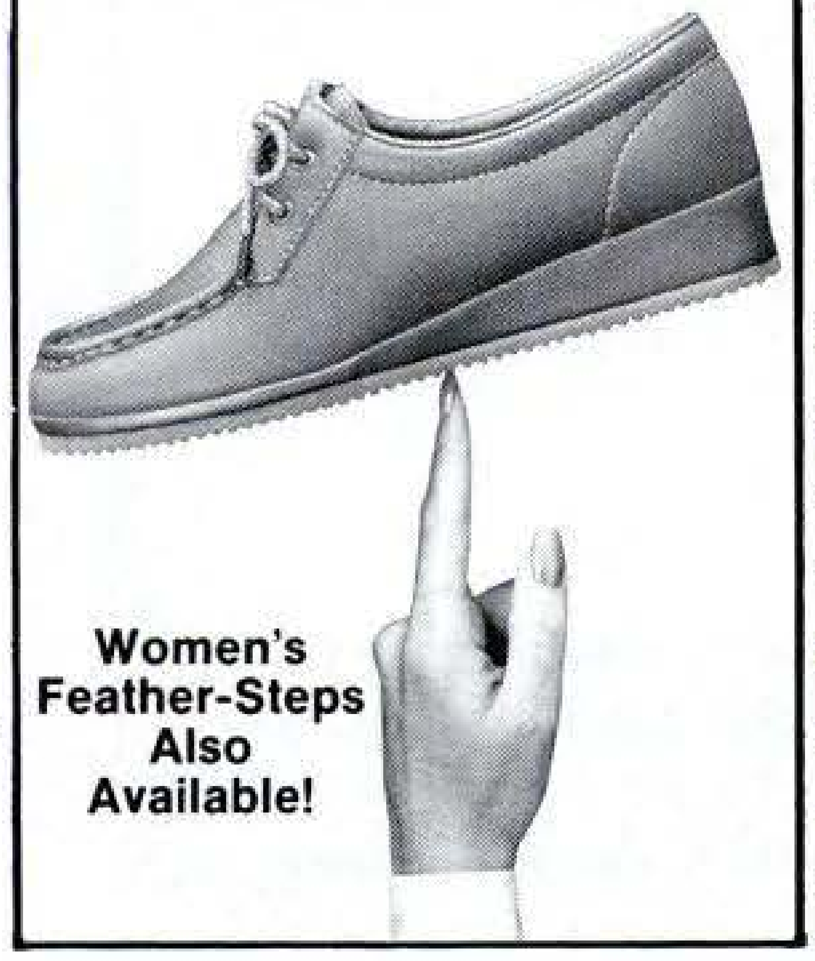

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Space junk

[*Continued from page 85*]

In the meantime, NASA will continue to explore political engineering to reduce the creation of new orbital debris. It has persuaded most Pentagon officials to conduct high-altitude weapons tests more safely and not to detonate satellites in a manner that leaves debris in orbit for centuries. That took some doing: In one notorious Air Force experiment, the barely functional Solwind satellite was destroyed by a high-flying F-15 jet, and the ensuing debris accounted for as much as one-tenth of all the material the United States has ever generated, according to Lamb of the University of Illinois. Recently, however, the Pentagon orchestrated the more responsible Delta-180 test, in which two Delta rockets flew together and exploded in the upper atmosphere, at a relatively low altitude that ensured that all of the debris would fall back to Earth within three months. NASA engineers were unanimous in their praise for the responsible manner in which the test was conducted.

Redirecting rockets

The next big step was convincing Japanese, European, and Soviet officials that their spent rocket stages should be empty in the future. There are more than 3,000 of the structures floating in orbit, and their contents—hypergolic propellants designed to ignite when combined—have often blasted new debris into existence.

That policy is history. Now NASA bureaucrats like Joseph Loftus travel around the world to encourage other space-faring nations to add propellant to their rockets. NASA's new goal is to convince space agencies worldwide to redirect rocket carcasses either *downward*, toward Earth, where they will be destroyed upon re-entering the atmosphere, or *upward*, beyond the altitudes at which most satellites and spacecraft congregate. "What you're really going to have to do is agree that as of [a set date] we're all going to adopt that as policy," says Loftus. "People are beginning to look at a practice of raising spacecraft out of a geosynchronous arc up to an elephant burial ground, if you will."

The last step, according to NASA, will be adopting agreements to require the retrieval of large pieces of space junk, possibly using robotic spacecraft that will be decades in the making (see box, Garbage Truck of the Future?). Without further human intervention, Loftus notes, some of the debris that our species has recently fired up into orbit may take five centuries to come back down. PS

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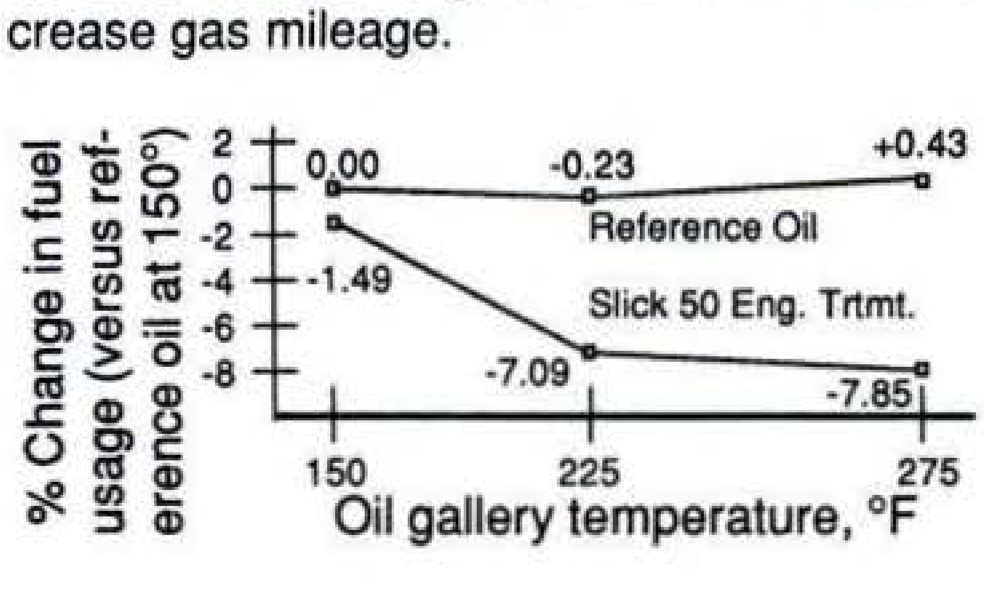
As with any lab test, these results may not translate exactly the same percentagewise for every engine under every type of driving condition in the "real world". However the conclusion for these test cases is clearly that Slick 50 does reduce engine wear and does increase gas mileage.



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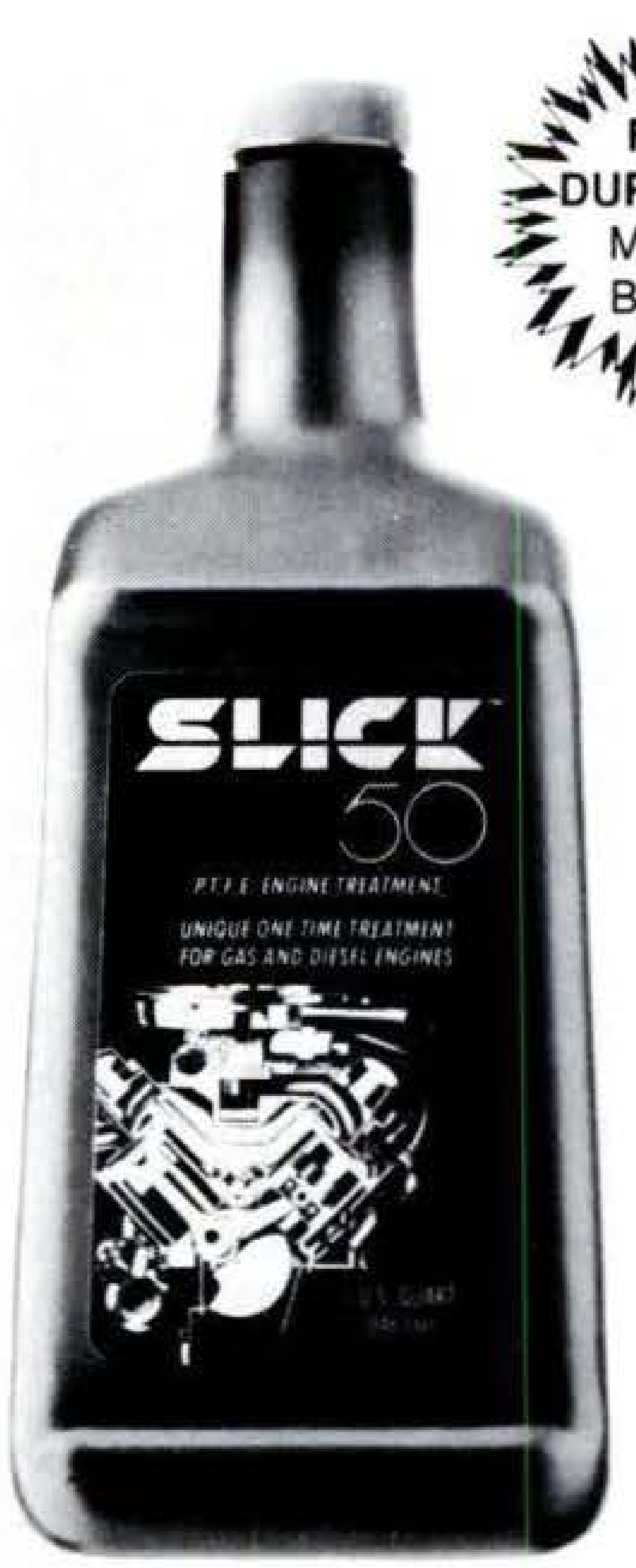
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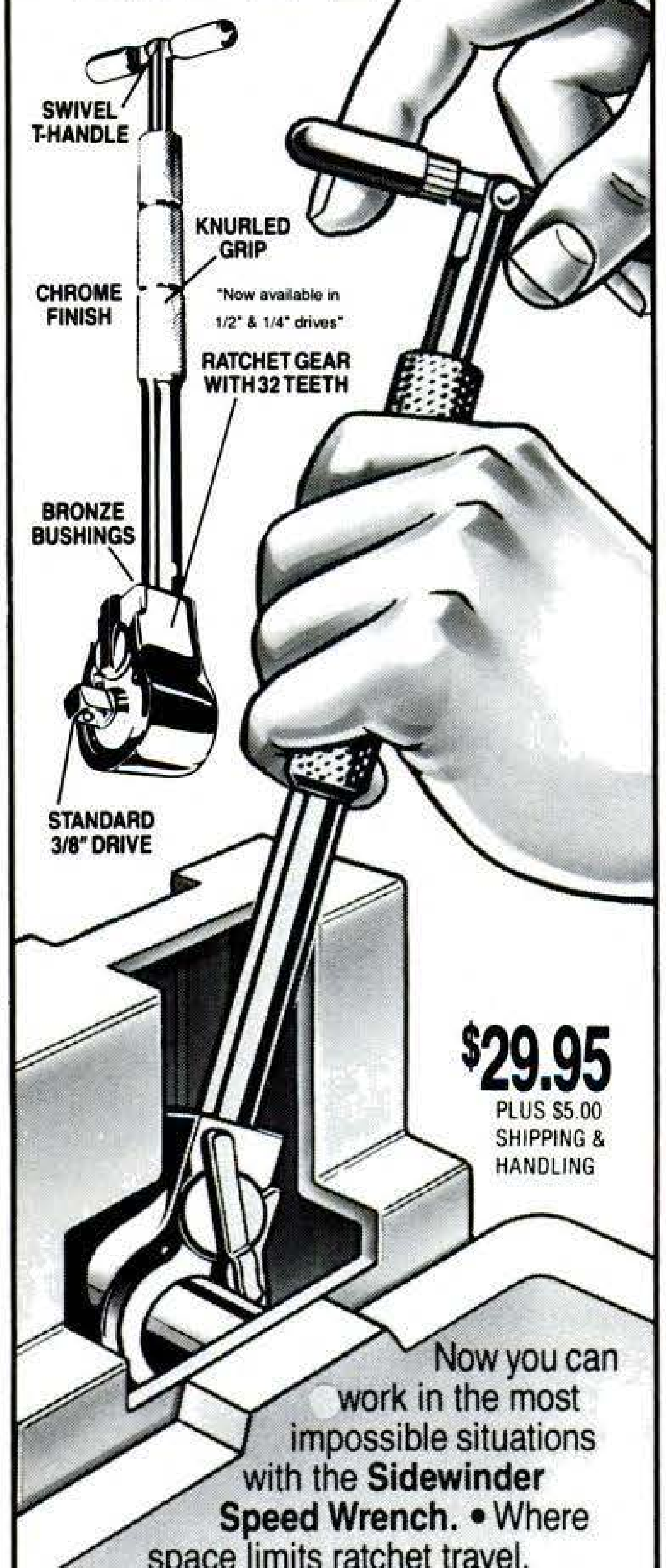

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Two-strokes

[Continued from page 75]

such a poppet-valve design, calling it the "flagship design." But others are quick to point out that conventional engine valves quickly run into an rpm problem when applied to a two-stroke.

"It's even worse than you might think," says Chrysler's Christopher Theodore, executive engineer of powertrain engineering. "It's not just that the valves must complete their cycle for each stroke—twice as fast as a four-stroke. The actual valve event must take place in about a quarter of the time." The resulting rpm limitation is apparent in the 3,600-rpm redline of the Toyota engine.

Dissenting views

Pondering the Toyota effort quickly leads to the one question that may yet derail all this engineering energy: Is the two-stroke really all that great an improvement over a fully developed four-stroke? One who thinks not is Gerhard Gruber, manager of engine pre-development for Audi, the company that in the late 1960s absorbed DKW, one of the last production two-stroke automobiles and the inspiration for the East German Trabant.

Horsepower, says Gruber, is where you find it. "Look at the slow speed the Toyota two-stroke is turning—what's the point? You could generate the same horsepower with a four-stroke at twice the crankshaft speed—the only difference would be in the gears in the transmission."

"I could wave my hand one way and argue one way, wave it the other and argue on the other side," says GM's Heimbuch. "A high-output turbocharged four-valve engine operates at more stress than an equivalent two-stroke."

GM is seeking simplicity and low cost, and even some elements of the Orbital design seem too complex. GM's Don Runkle says a high-pressure injection without the air injection could also atomize fuel properly, but the jury is out on which system would be lower in cost. "We favor the simple approach," he adds.

As does Orbital. Still searching for a major automotive customer for its engine, Orbital has already released a second generation of two-strokes that answers most of these questions. Particularly elegant is an externally scavenged wet-sump version of the basic three-cylinder that tucks the scavenge pump behind the flywheel where it doesn't add to the overall dimension of the engine. A V6 producing about 200 hp likewise enlarges the scope of cars that could use the two-stroke. That engine is likely to see service first in a marine application. Several outboard motor manufacturers also are licensing the air-injection fuel-delivery system from Orbital.

Ultimately, the acceptance of the two-stroke engine will be based on proof of its two major claims: that it is inherently more fuel efficient than a four-stroke, and that it can at least meet current and future emissions standards. The fuel-efficiency claim is based on several factors. One is that it has less "pumping loss" than a four-stroke, because it doesn't waste a stroke sucking air and fuel into the combustion chamber. This is demonstrable, but the advantage is lessened when you subtract shaft horsepower going to an external supercharger —the two-stroke's air pump.

A trickier issue is the claim for stratified charge combustion. The so-called "lean burn" engine has eluded auto engineers for several decades, but now some are admitting that the direct-injection two-stroke appears to burn at extremely lean mixtures, at least at low rpm. Combined with the low pumping losses, the two-stroke thus becomes highly efficient at idle and low-power outputs—just where most driving is done. Interestingly, the strides made in stratified combustion for two-strokes appear to have revived interest in a stratified-charge four-stroke as well.

But the most critical issue concerns two-stroke emission claims. "We know it meets it, but we don't know what happens after 100,000 miles," says GM's Heimbuch.

Partial solution

Controlling combustion is only part of the answer. Most of the designs have a shutter-type valve in the exhaust port that effectively adds some exhaust-gas recirculation to reduce NOx emissions. (Subaru uses a flat rotating exhaust valve—the type used in some motorcycle engines.) The relatively cool exhaust presents a catalyst light-off problem, which Orbital addresses by putting a small catalyst directly in the cylinder head.

The emissions issue depends on the new generation of emissions laws. If standards are too stringent, the two-stroke in the United States could be dead. That wouldn't necessarily cool interest in Europe, Japan, or even underdeveloped countries. A compact, low-cost fuel-efficient power plant could mean an advance in personal transportation that could put the 80 percent of the world that currently lacks mobility on wheels.

"But you know," a young GM engineer told me. "I'd like to have a car like that here." PS

Look who's calling

[Continued from page 78]

is to open your front door without knowing who is knocking."

Sen. Herb Kohl of Wisconsin likes the peephole analogy. Introducing the Telephone Privacy Act of 1990 to Congress, he said: "My bill would require phone companies that sell Caller ID to give callers the option of blocking the display of their phone numbers." (You press a few buttons on your phone, and the recipient sees PRIVATE on his screen.) "The blocking option gives the caller more privacy, but the recipient nevertheless obtains more information than is available at present. And the recipient always retains the right not to answer. By way of analogy, a homeowner can refuse to open the front door when a visitor covers the peephole."

Hello, it's me

The phone companies fighting Kohl's bill say few customers have complained about Caller ID, and the blocking option would ruin the new service. Not true, Kohl told Congress. "Callers will not block calls to their friends and colleagues. They will permit their numbers to be displayed as a way of saying, 'It's me, so pick up the phone.' "

A variety of groups—including Ralph Nader's Public Citizen, the ACLU, the Consumer Federation of America, and the National Association of State Utility Consumer Advocates—have endorsed Kohl's bill. President Bush's Special Adviser for Consumer Affairs, Dr. Bonnie Guiton, stated: "If residential consumers can be offered a blocking mechanism in conjunction with Caller ID, they will be able to take back some of the privacy they have already lost."

Pacific Bell will offer the blocking option in 1992, when Caller ID becomes available in California; the state legislature passed a law requiring it. And bills to require blocking are pending in Maryland, Virginia, Illinois, and New York. In Pennsylvania, a judge ruled that Caller ID violates the state's anti-wiretapping law, but the state's Public Utilities Commission nevertheless approved the service—without blocking, except for violence intervention agencies, law enforcement officers, and others who apply for special permission. The ACLU and groups representing battered women appealed the decision, and the Commonwealth Court has temporarily blocked introduction.

Cutting off the calls

As the debate continues, phone companies are already developing the next generation of privacy features. The companies don't want customers to be able to block outgoing numbers, but they are working on ways to block most incoming calls. Customers using one proposed service—Selective Call Acceptance—would program their phones to reject calls from all but a few designated numbers.

And before long, systems from developers like CDT and Bellcore might have built-in directories. CDT's phones would display a caller's name as well as his number. Bellcore's latest trial system includes a phone device you needn't even look at. When someone calls, its internal system recognizes the number, matches it with a listing from the phone book, and announces—via a speaker—who's calling.

But despite all this technological sophistication and convenience, ultimately, Congress and the courts will have to decide who owns your telephone number—and who has the right to reveal it. Until then, advises Zachok of Bell Atlantic, "assume people have your number." PS

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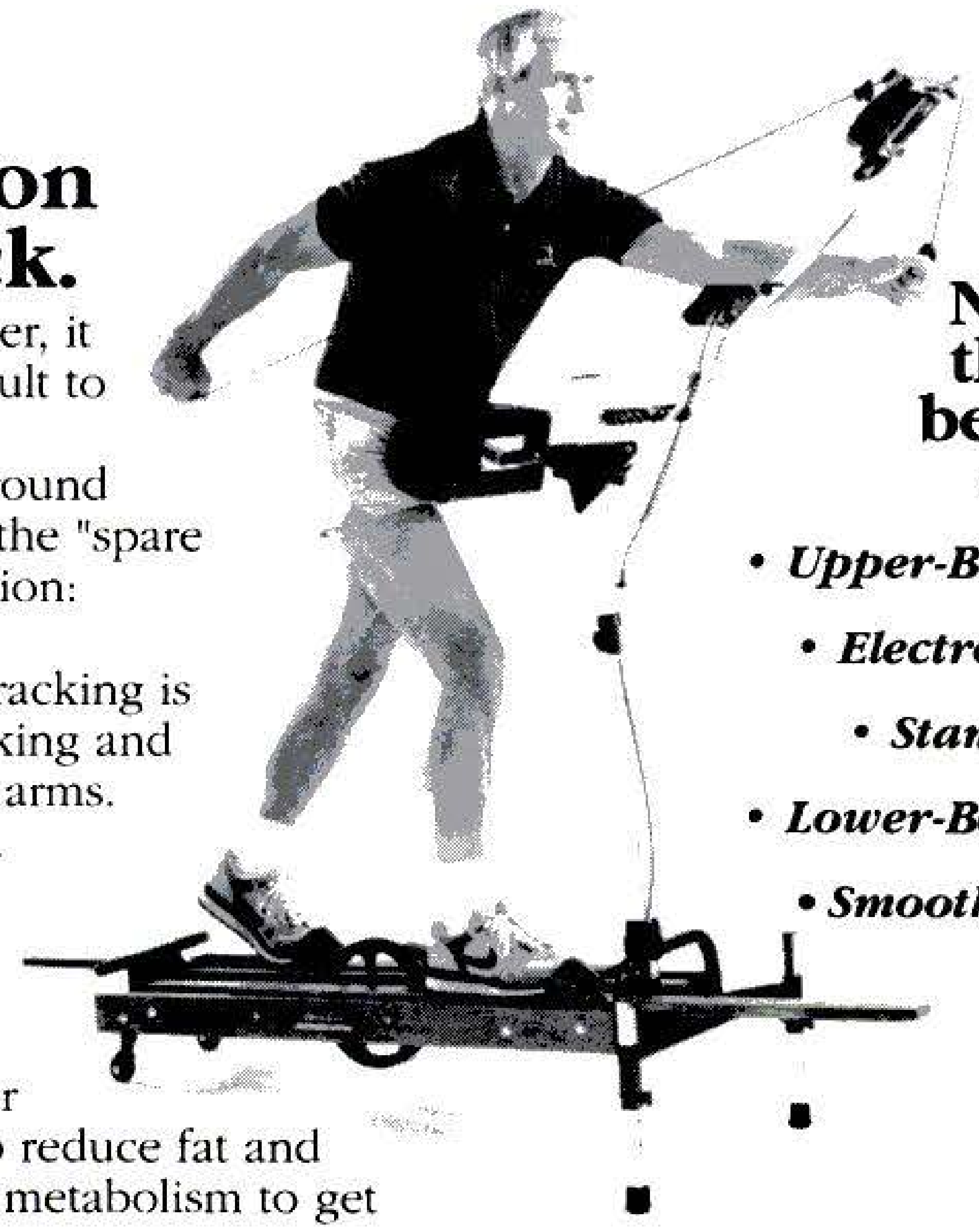

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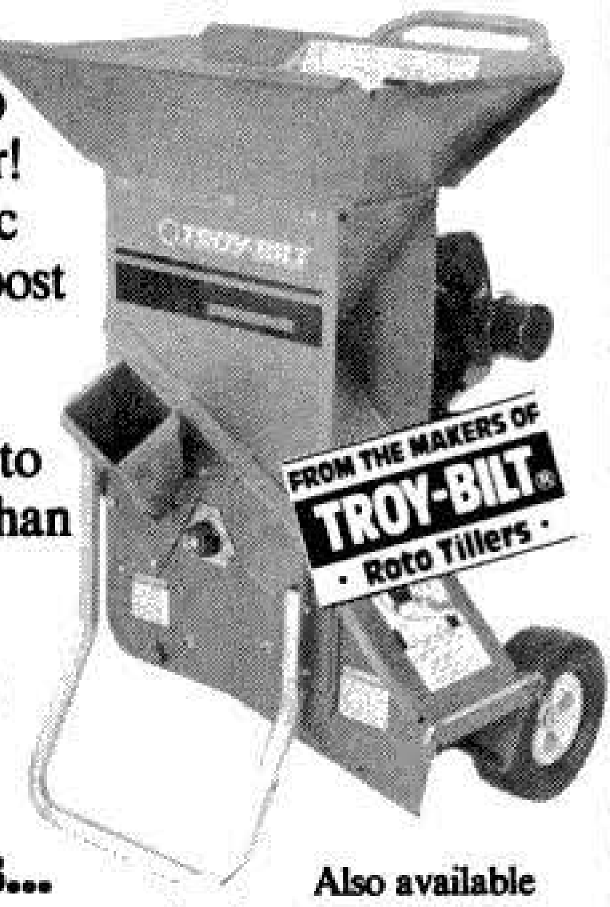

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Canned squeals

In the last few months, I've seen a number of car commercials on TV promoting anti-lock brakes. These ads all use the sound of tires squealing, which confuses me. It seems that with ABS there should not be any tire noise. Are those sounds added in during the editing process?

James V. Grisham, Spokane, Wash.

When an ABS system is working as designed, it will not allow a wheel to lock up. The system's sensors will detect the rapid slowdown of wheel rotation and release the brakes before the wheel stops turning and begins to skid. It's plausible that the tires might make some noise when they are stressed to the point approaching lockup. On the braking portion of a road test you can hear this as an intermittent chirping from outside the car. The truth is, though, that the TV ads probably do add the noise for dramatic effect.

Hot starts

My 1976 Buick Le Sabre starts and runs fine when the engine is cold, but refuses to start when hot. It acts like a dead battery or dragging starter, but I've had both replaced to no avail. Do you have a solution?

William M. Warren
Bradenton, Fla.

This is an old, old problem that usually is caused when the starter solenoid heats up from the exhaust manifold. The way to check this is to duplicate the condition and have the current draw checked with an ammeter connected to the starter circuit. If you find an abnormally high current draw, the solenoid is probably the culprit. If the exhaust system is cooking the starter, you'll have to either insulate it or cool it with an air duct. Also, make sure your battery cables have sufficient capacity.

Smelly exhaust

In December 1989 I bought a 1990 Chevrolet Lumina sedan with the 2.5-liter four-cylinder engine. Since the day I took it for a test drive, I've noticed a strong smell of rotten eggs. Where is the stink coming from?

Willard M. Ream, Levittown, Pa.

Your foul-smelling exhaust is a product of the pollution-control equipment and sulfur in gasoline. Specifically, the unburned fuel that passes through the engine is being burned in the catalytic converter, and you are smelling the sulfur that is contained in the fuel. My suggestion is to shop around for gas that has less sulfur in it. Check with your dealer for factory service bulletins regarding this problem.

Hissing on fill-up

When I take the gas cap off my 1990 Cadillac Brougham, I hear a loud hissing noise. When the tank is half empty, it is hard to even open the cap. The dealer says this is normal. What's wrong?

Anton M. Lippeth, Freeport, Ill.

The hissing coming from your gas tank is caused by a partial vacuum that develops as fuel is used. To decrease the amount of fuel vapors that can escape and cause smog, the fuel system of a modern car is a closed loop, with vapors being captured and sent to a collection canister. It makes sense that the lower the fuel level in the tank, the greater the vacuum, so I doubt you have a problem that requires repair.

On the thin side?

I've been using Mobil 1 synthetic oil in my car and recently read that this type of oil will not stick to engine parts as well as mineral oil, so when the car is started some parts must run without lubrication. Care to comment on this?

John Engelhardt, Coram, N.Y.

Years ago, synthetic oils were known for rapidly draining off internal engine parts, sometimes giving up corrosion protection when the cars were not run for long periods. Newer premium grade synthetics have solved that problem though. All engines, regardless of the oil used, need to be treated carefully on cold starts because of the lack of immediate oil pressure.

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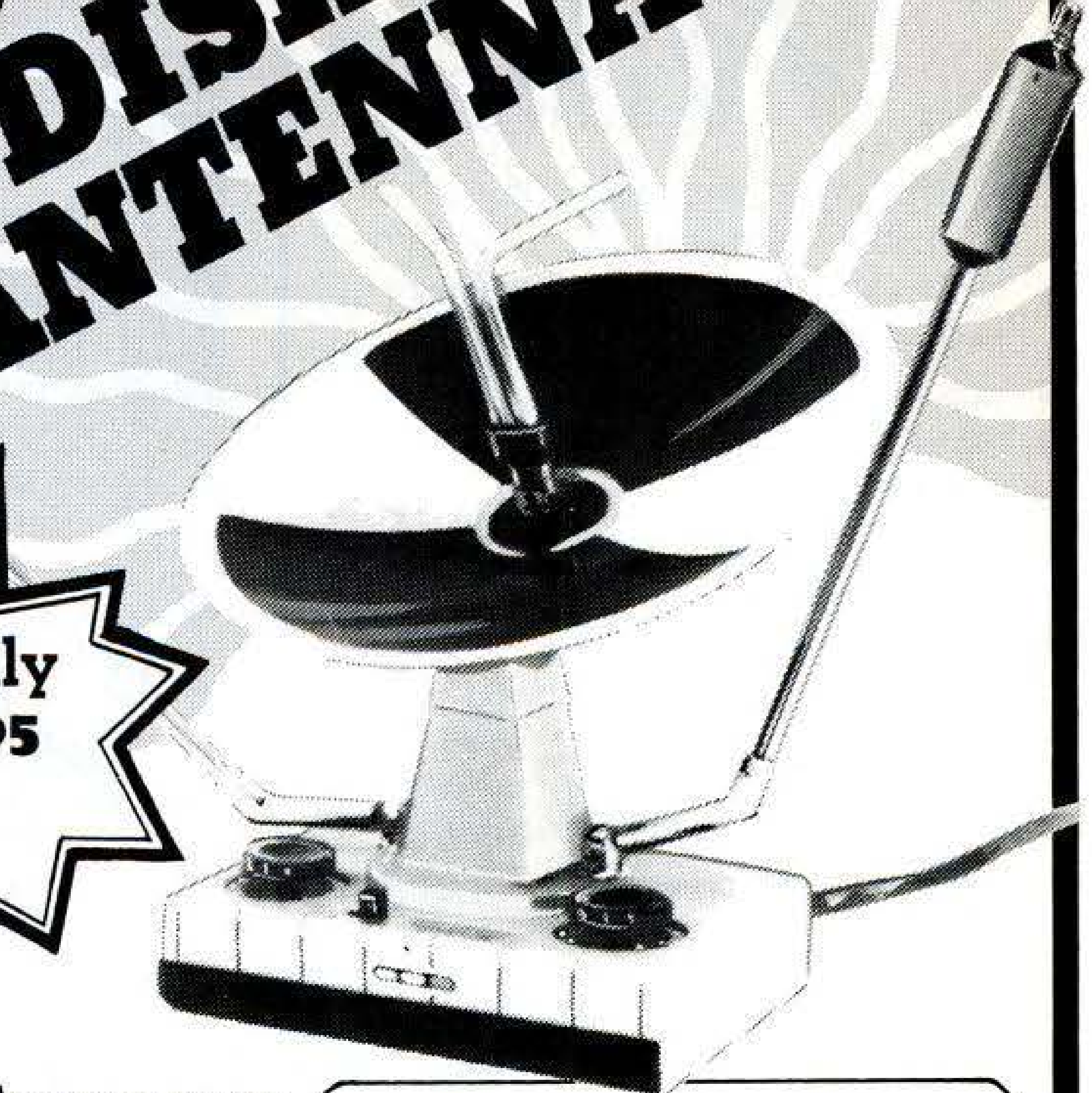

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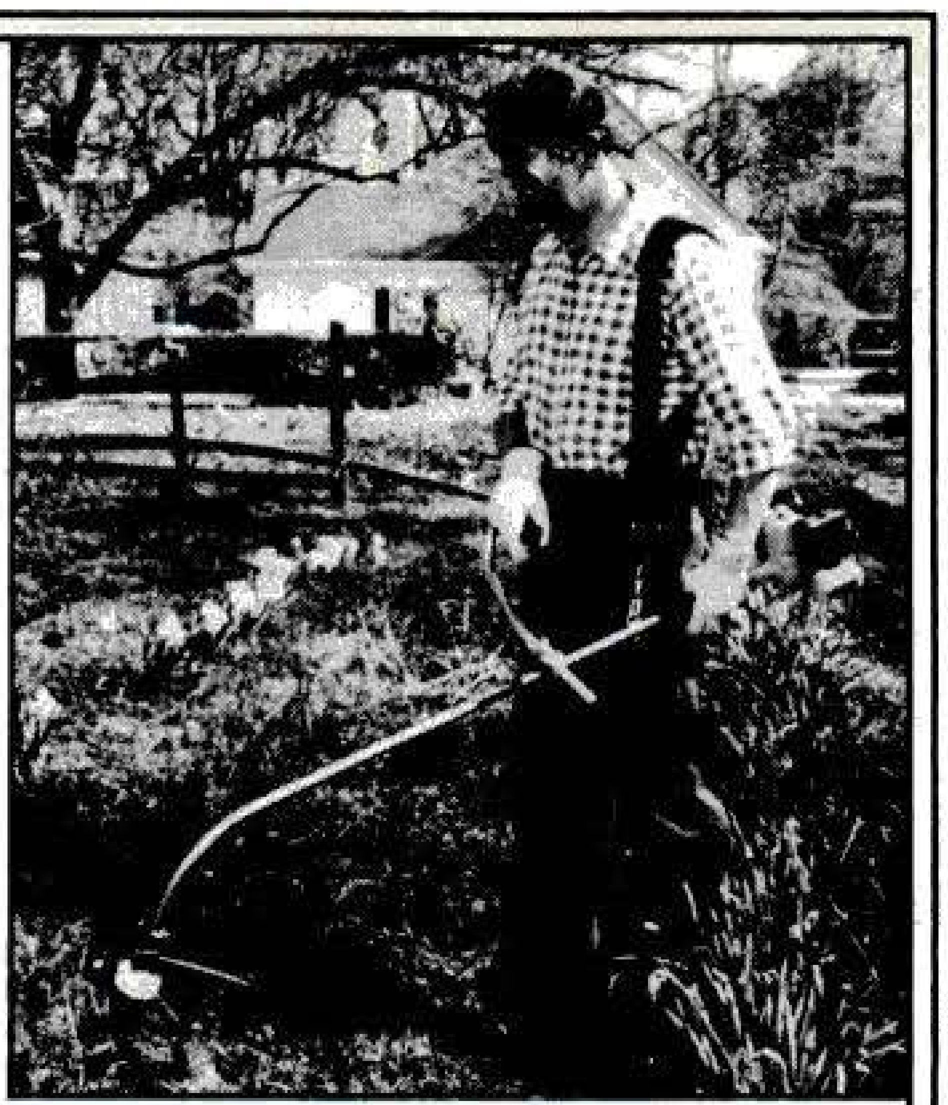

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"Say, Smokey—"

Oil shelf life

I am interested in your opinion as to the feasibility of using motor oil that has been in unopened cans for six years. Are there any detrimental effects to the oil or its additives?

John R. Gavlick, Covina, Calif.

I think your concerns are real, but I haven't heard that oil has a finite shelf life. With some graphite oils, I've seen the graphite settle out in the can; this was a serious problem for early synthetics as well. And, for mineral oil, I expect that the heavier ingredients can settle if allowed to sit for a long while. Gas station owners used to flip the cans over to mix the contents periodically.

Oil for a Spirit

I recently purchased an almost new 1989 Dodge Spirit whose manual recommends the use of 10W-30 grade oil. I live in West Texas, where it can easily get to 95 degrees F during the day. Will this oil protect the engine, or should I use a straight 30W oil during the summer?

B. L. Williams, San Angelo, Texas

Number one in importance is not the viscosity of the oil, but that you always use the type recommended by the manufacturer. For the best protection, the same old advice applies—use a premium-grade oil as recommended in the owner's manual and change it frequently.

Foxy smell

I just bought a 1987 Volkswagen Fox. The previous owner replaced the radiator and water pump, and when I warm up the car I can smell antifreeze. Is there a problem with the heater core?

Martin Altis, Pequannock, N.J.

You're on target. If you smell any antifreeze, it's certain you've got a major leak. It can be hard to find though. I suggest using a leak-detection dye that glows under ultraviolet light; most radiator shops will have this equipment. A logical place to start is at the heater core, but it could come from a blown head gasket or a leaking hose.

Got a car problem? Send it to "Say, Smokey—," POPULAR SCIENCE, 2 Park Ave., New York, N.Y. 10016. All letters are read, and those of widest interest are answered in this column. Due to the large volume of mail, Smokey cannot reply to letters not selected for publication.

Shoppers' Showcase

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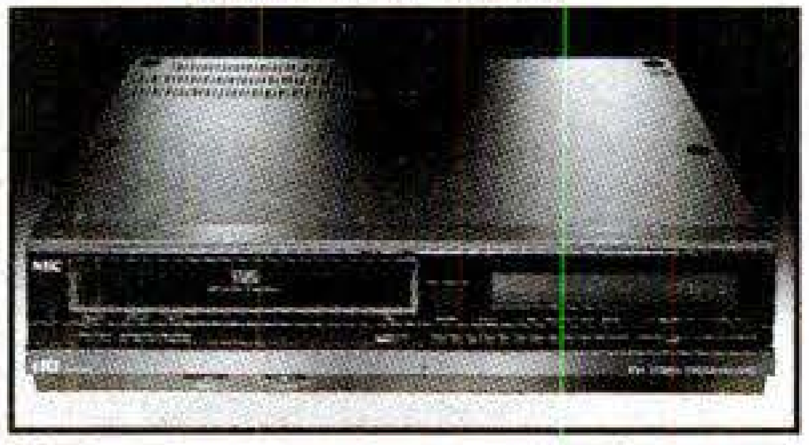

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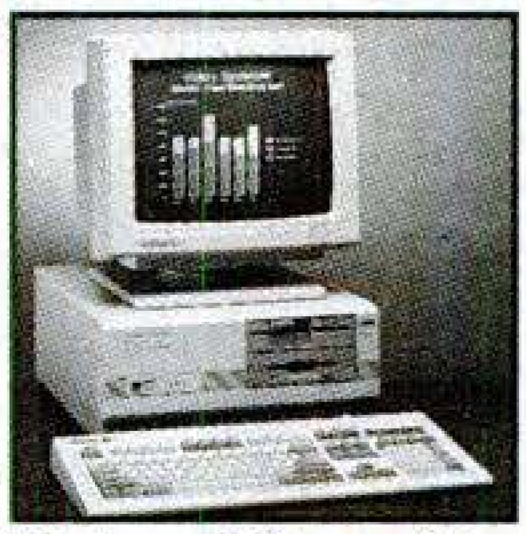

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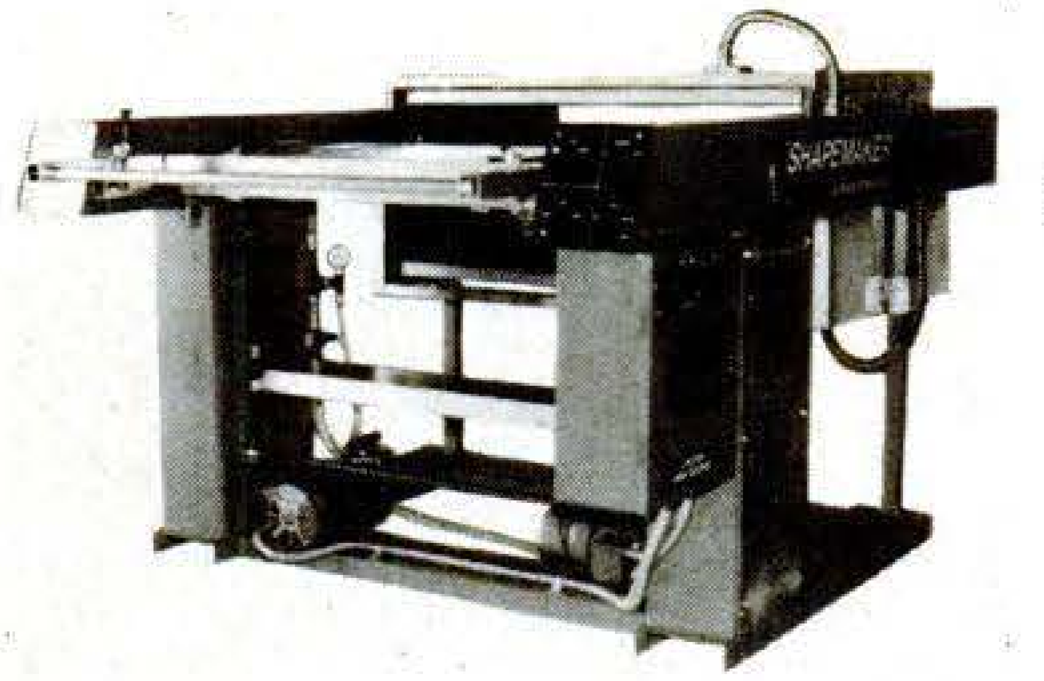

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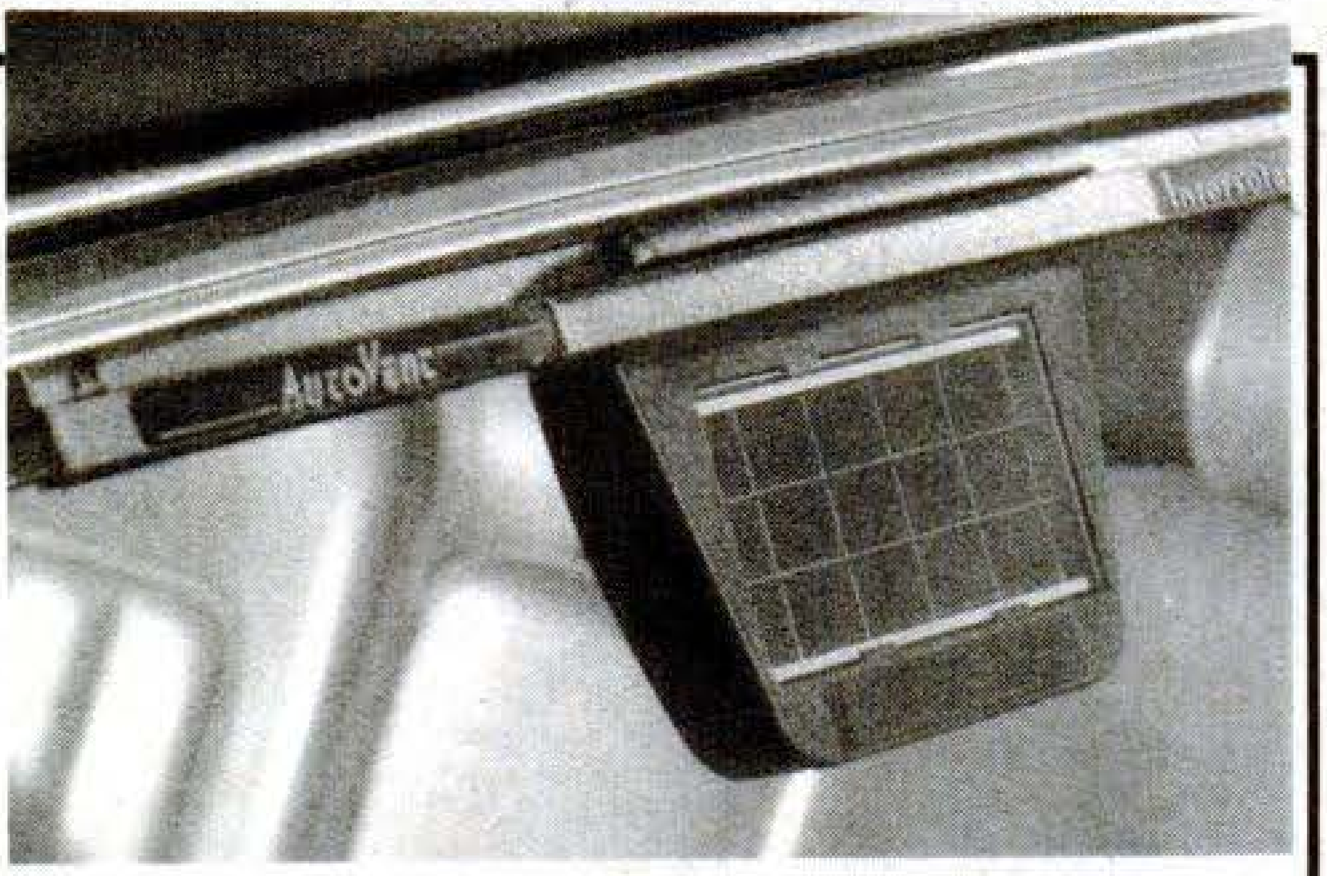

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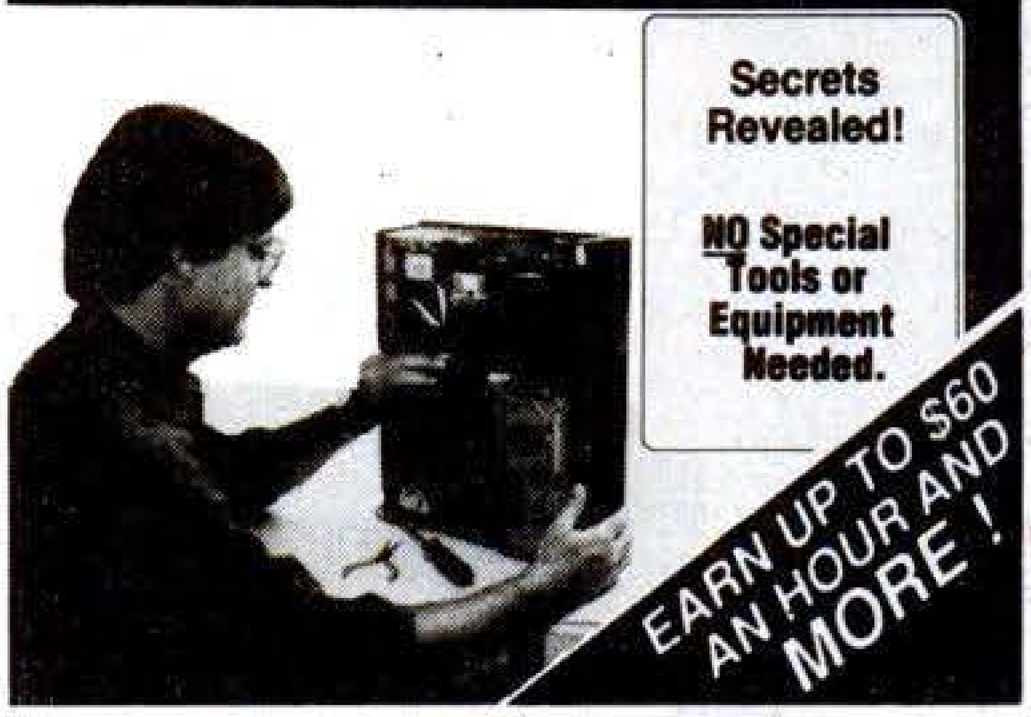
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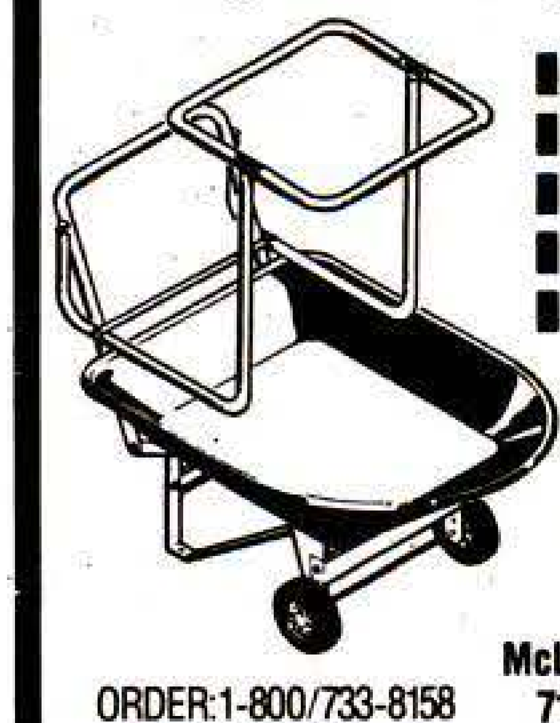

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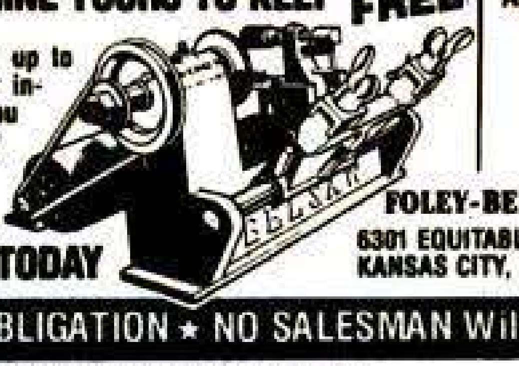

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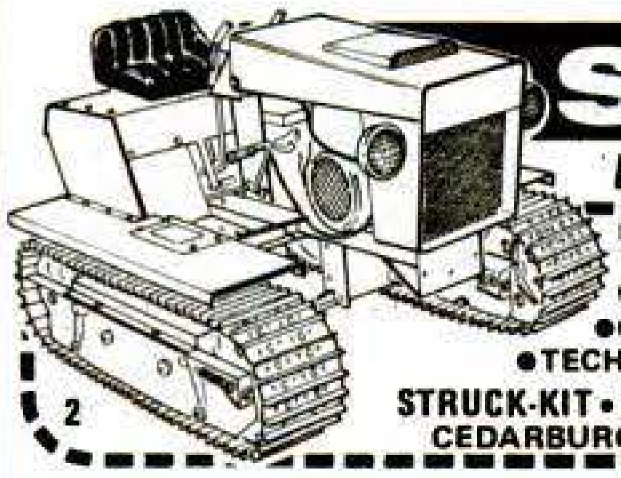

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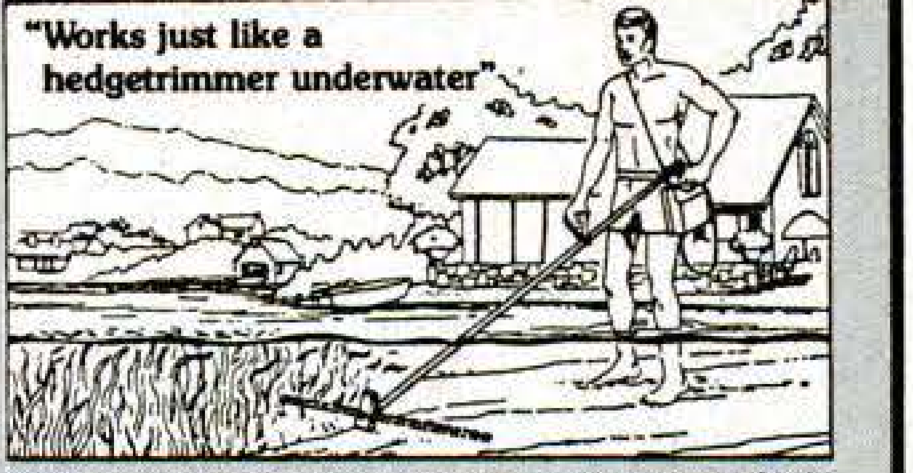
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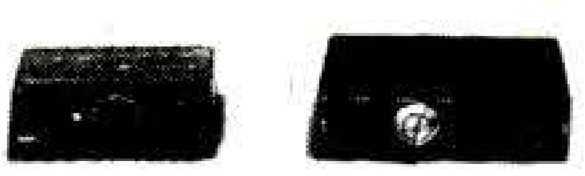

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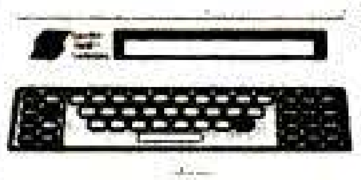

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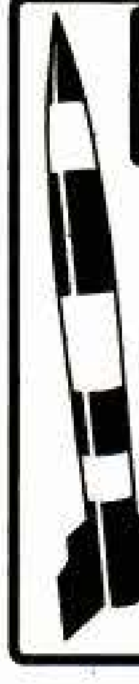

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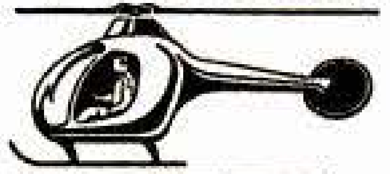

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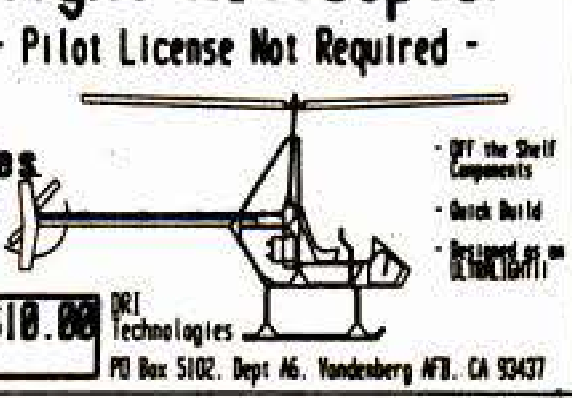

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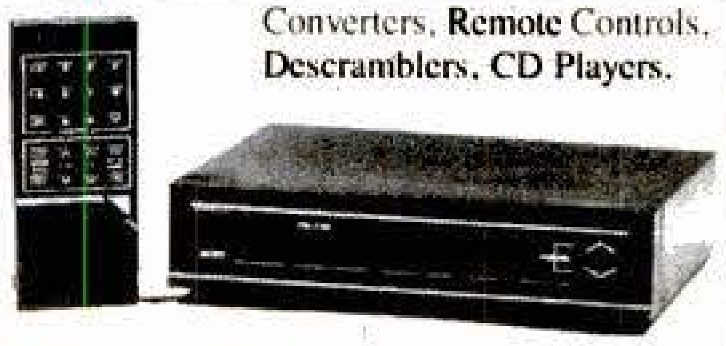

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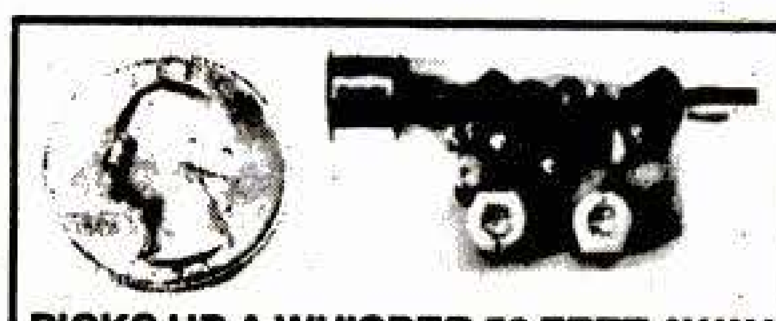

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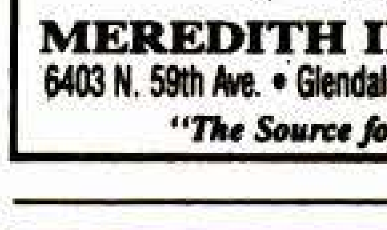

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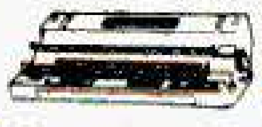

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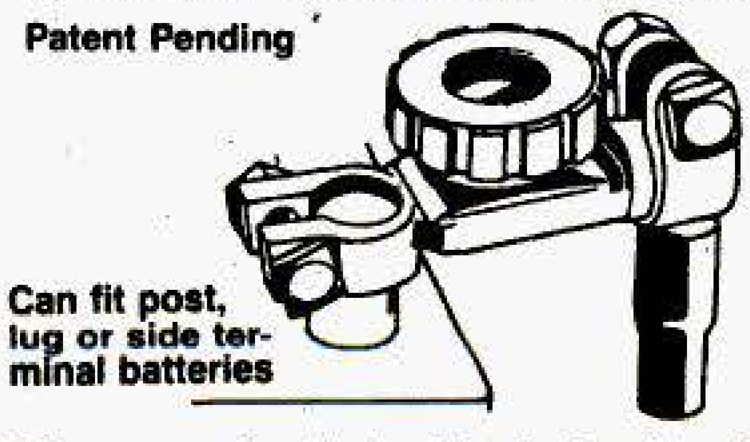
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702 Radar Detection A Bel-Tronics brochure explains Ka Band photo radar equipment. Some of the questions addressed: Is photo radar legal? Is photo radar the only type of equipment that can be used at Ka Band? Free

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719 Car Care U.S. Auto-Tech's new full-color car-care catalog describes its line of unique engine and gas-saving products. Also featured is the KolorKey carnauba car wax that is safe on all types of car finishes, doesn't leave swirl marks, and comes in 10 colors, including burgundy, silver, and black. $1

720 Deck-Care Products Two brochures are available form Wolman: "Treat Your Deck to a Longer Life" shows how Wolman Deck Brightener, RainCoat Water Repellent, Deck Stains, and Clear Wood Preservative help restore and protect pressure-treated wood decks against the harmful effect of water. "Treat Your Deck to the Rich Warmth of Natural Wood" shows how Wolman RainCoat Water Repellent gives you immediate water repellency. Free

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POPULAR SCIENCE JULY 1990

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THIS COUPON EXPIRES SEPTEMBER 30, 1990

Looking Back...

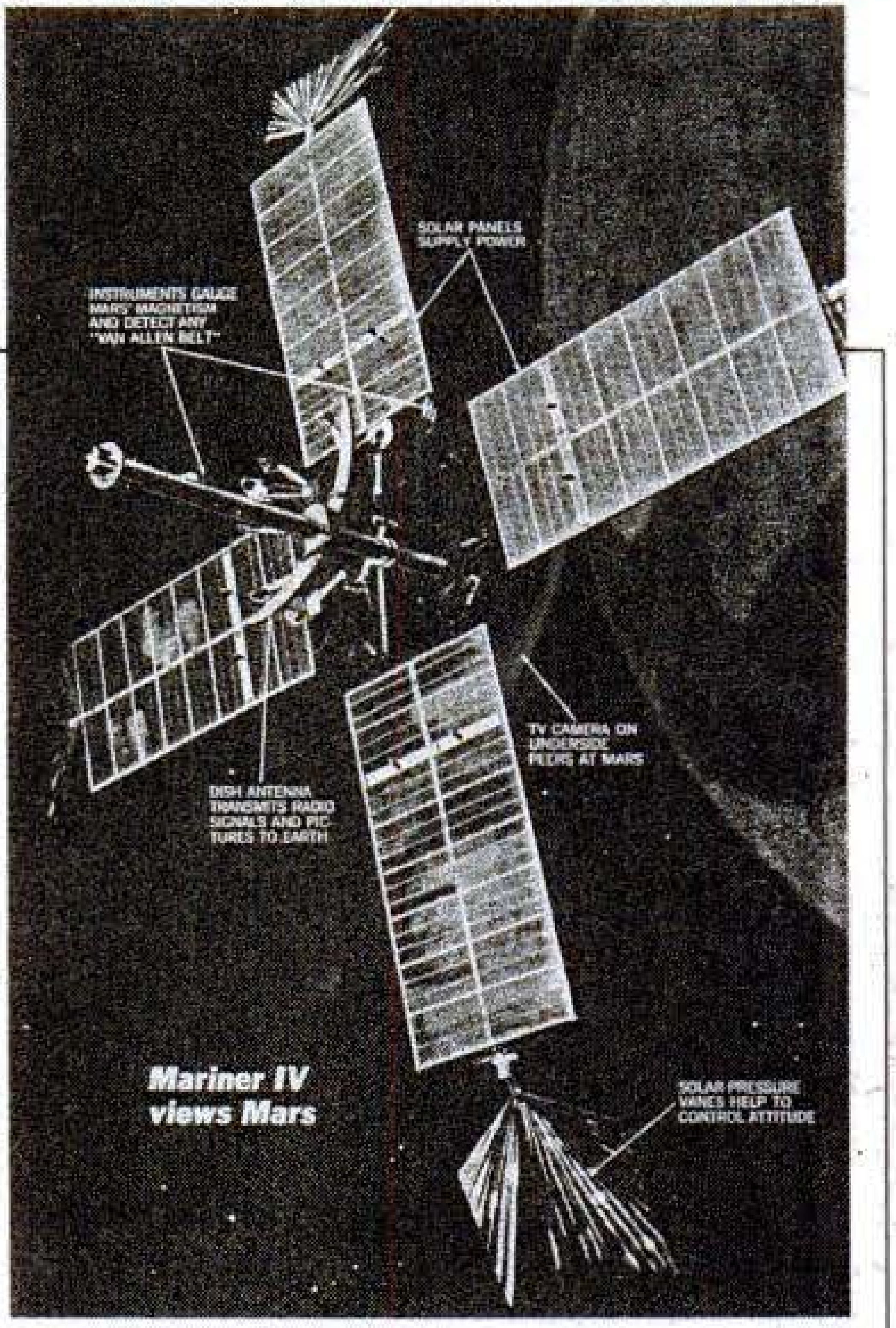
Sampling a century of Popular Science

25 YEARS AGO JULY 1965

"Will our Mars-bound Mariner IV spacecraft triumphantly bring us the world's first close-up photos of the mysterious Red Planet? Or will it fall prey to a heartbreaking mishap, like the radio failure that's put its Soviet rival, Zond 2, out of the running?

"We'll soon know. On July 14, windmill-shaped Mariner will reach Mars's orbit just as the planet speeds by. A telescopic TV camera aboard Mariner is due to shoot 18 photos of the sunlit martian surface at a range of only 7,370 to 9,570 miles—compared with Mars's minimum distance from Earth of 35,000,000 miles. From Mariner, Mars would look as big to the naked eye as a 12-inch globe at arm's length. If Mariner gets its photos, the best one will show martian features as small as two miles across."

On Nov. 28, 1964, Mariner was successfully launched from Cape Kennedy and passed Mars on July 14, 1965. NASA's Jet Propulsion Laboratory received 21 TV pictures during the following 10 days. These were the first close-range pictures of another planet (see "Becoming Martians," June).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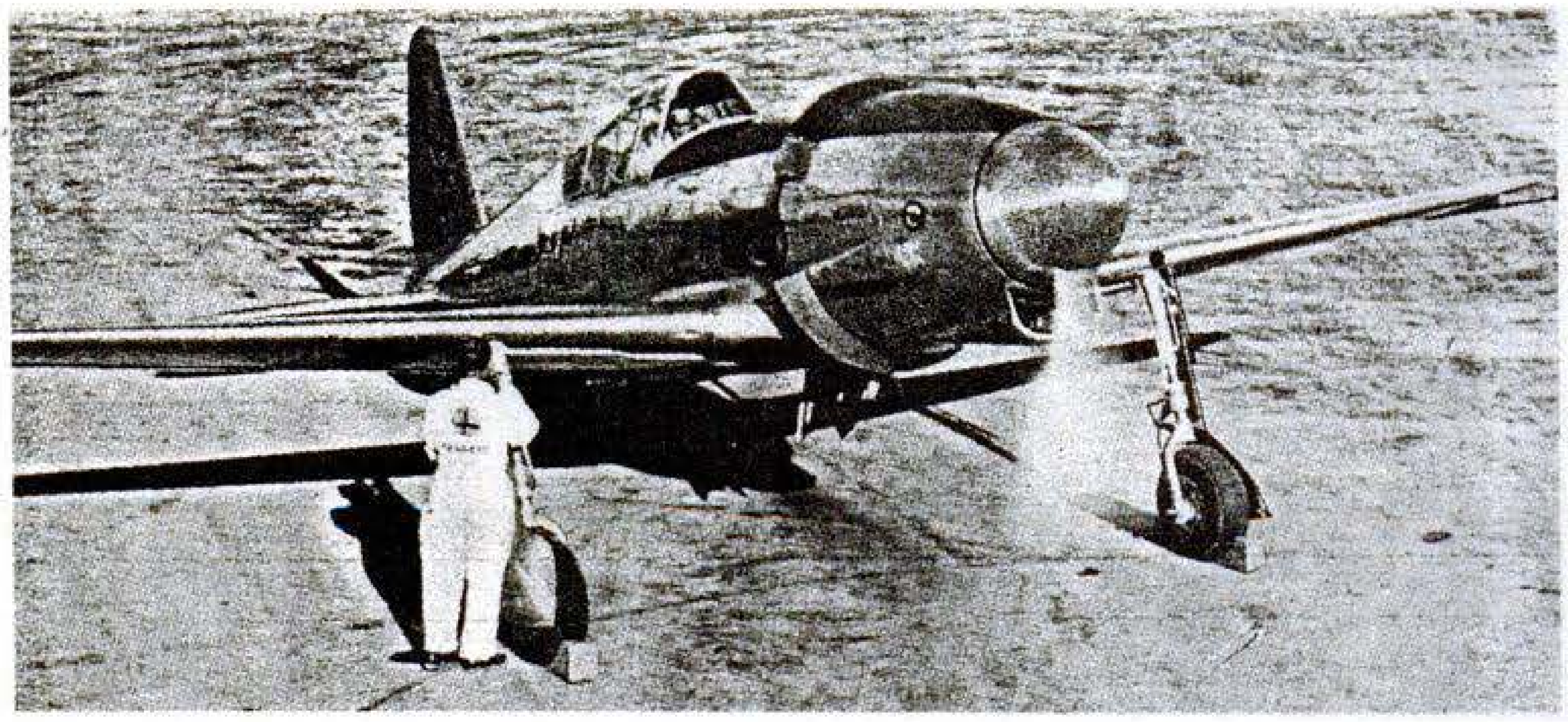
Mariner IV views Mars

50 YEARS AGO JULY 1940

"Johnnie Wagner sucked at his oxygen tube and began talking into the mouthpiece of a recording device. 'Altitude 15,000. Stabilizing at full throttle for speed run....'

"Less than five minutes before, Johnnie had lifted the new Vultee Vanguard from the narrow runway below, climbing some 4,000 feet a minute. Now he was streaking like a scared rabbit across the sky, hitting close to 400 mph.

"Johnnie that day was testing the newest warplane. She was not a souped-up racer intended to compete for speed laurels, but a production model, which in coming weeks may be spitting lead from four machine guns across the Western Front. Upon her ability to rise nearly eight miles, and to roll, loop, stall, and recover for chases through the sky faster than other warplanes in her class, Vanguard may have fighting pilots shortly depending for their lives in grim but thrilling combats."

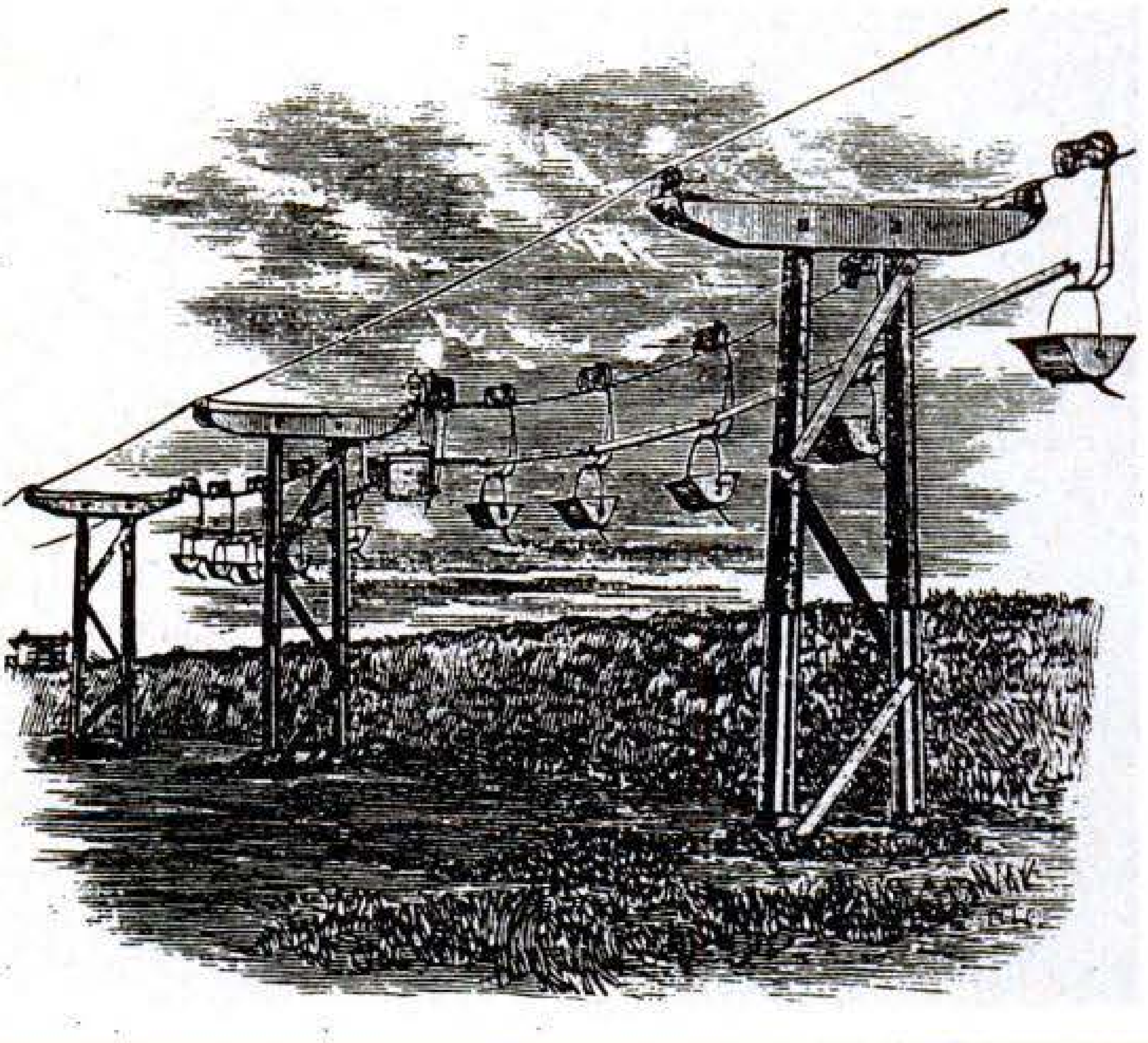


100 YEARS AGO JULY 1890

"A vast field of application, which electricity is only just entering upon, is the transportation of freight and passengers. The use of electric motors for propelling passenger cars on street railways may be said to have passed through the experimental stage into the domain of commerce.

"The system, called Telpherage, may be regarded as a development of what is called in England the 'wire-rope haulage' system, by which freight is conveyed in buckets suspended by a grip from an elevated wire cable.

"In regard to possible applications of telpherage, Professor Perry, one of the co-inventors, has said: 'It will not only be very useful in bringing ore from mines, but it is easy to arrange for a line, which will load or unload a vessel that can't come into shallow water...telpherage will be a general system of distribution of goods in the future. This is a fact that is fixed in my mind quite securely.'"



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